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THE NEW YORK NAVY YARD will build one of the new battleships, according to the order issued by Secretary of the Navy Moody on July 7. This battleship—either the "Connecticut" or the "Washington"—will cost $4,212,000 for hull and machinery. The $175,000 set aside for preparing a navy yard to do this work will be expended in Brooklyn in building a large overhead traveling crane, the machine tools required being on hand. The choice lay between Brooklyn, Boston and Norfolk, but the first-named place has the advantage in the transport of the 16,000 tons of steel required, and in an abundance of skilled labor. The estimates allow $3,000,000 for the hull, $1,000,000 for machinery, $250,000 will go to Admiral Bradford's department, and the armor and guns will cost about $2,000,000 more. Of the total cost of the ship, about $2,000,000 will be expended for labor.

A WIRELESS TELEGRAPH STATION is to be built by the government on the Navesink Highlands. By means of this station the government expects to be able to communicate with the Brooklyn Navy Yard and with its ships many miles at sea. It will be the first station constructed by the United States Government.

COMPETITIVE DESIGNS FOR STREET RAILWAY protective devices are asked for by the city of Dresden, Germany. Prizes of 5,000, 3,000 and 2,000 marks (1 mark = 23.8 cts.) are offered for the three best designs, and the city will in addition pay royalties for the use of the devices (fenders, etc.) adopted. We are indebted for the above information to the Patent-bureau F. Weidl, Jahnstrasse 2, Dresden A, Germany, from whom the conditions of competition and any additional particulars may be obtained free of charge.

BOILER INSPECTION AND SMOKE PREVENTION are provided for in an ordinance passed by the Chicago city council on June 30. It creates a new department, to be known as the Department for the Inspection of Steam Boilers and Steam Plants; this will be composed of the city boiler inspector, the city smoke inspector, and a supervising mechanical engineer. This board will not only make inspections (of which 30 days' notice are to be given), but will also conduct prosecutions for violations of the smoke ordinances. The provision which is expected to produce the greatest benefit in preventing smoke is that stipulating that every plan for a new building shall be examined before a building permit is issued. The plans must show that the building is to be equipped with a plant capable of preventing dense smoke or the permit will not be issued. Any person who reconstructs a building without submitting these plans shall be liable to a fine of $25 per day. If, when inspecting a steam plant, the inspector shall find that the furnace or firebox is so constructed or operated as to make the emission of dense smoke inevitable he is given the authority to require alterations. The owner may, however, put in any device he may think is capable of preventing smoke, but will be held responsible for the result of the experiment. Boilers are to be inspected every year, with the exception of low-pressure boilers (for which not more than 10 lbs. of steam are permitted), every three years. The fees for inspection are from $3 to $5 for boilers and $1 for tanks and jacket kettles, after the first inspection shall have been made.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Pere Marquette R. R. at Williamsburg, near Traverse City, Mich., on July 4. A special excursion train was being sidetracked to let a fast through train pass, when the latter came along at high speed and struck the engine of the excursion train. The engineer was killed and the fireman fatally injured.

TWO FATAL TROLLEY-CAR ACCIDENTS occurred on July 4. The first was the derailment of a runaway car on the Mountain Lake Railroad near Gloversville, N. Y. According to present reports, an open car coming down a long, steep grade was run into by a heavy closed car following, which had got beyond control. Both cars rushed down the grade together and jumped into the ditch when they struck a curve at the foot of the hill. Both cars were crowded with excursionists, and in the wreck twelve persons were killed outright and a large number of others seriously injured; one of the latter died on the following day. An investigation of the wreck has been instituted by the State Board of Railroad Commissioners.—The second accident occurred in Boulder, Colo. A motor car with several trailers, all crowded with people, ran away down a grade; the train tipped over when it struck a curve at the foot of the hill. Over a score of people were seriously injured, one of them dying shortly afterward.

A DAM OR RESERVOIR FAILURE near Attica, N. Y., is reported as having been caused by floods on July 6. The reservoir belonged to the Attica Water Supply Co. The east end of the dam at Attica Mills was also damaged.

THE UNIVERSAL METER SYSTEM AT PITTSBURG, Pa., and new mains and hydrants in the downtown district, have been recommended by an investigating committee of the city council, of which Mr. W. S. Woods was chairman.

BIDS FOR A SLOW SAND FILTRATION PLANT at Providence, R. I., are to be received until July 15 by Mr. Robt. E. Smith, Commissioner of Public Works. The work will include a dam across the Pawtuxet River, excavation for beds, pipe systems, filtering material, buildings for pump-house, regulator house and laboratory, movable sand ejectors, sand washers, sand cars and permanent and portable railway track. The plans and specifications may be seen at the office of Mr. Otis F. Clapp, M. Am. Soc. C. E.

THE NEW ORLEANS SEWERAGE PURCHASE case has been decided by the State Supreme Court in favor of the Sewerage and Water Board, so there appears to be nothing to prevent the latter from completing the purchase of the few miles of sewers built by the New Orleans Sewerage Co. Bids for constructing 98 miles of sewers are to be received by the Sewerage and Water Board until Aug. 12. Plans and specifications for the work may be seen at the office of Hering & Fuller, Consulting Engineers, 170 Broadway, New York city. Mr. Geo. G. Earl is general superintendent of the board.

SEWAGE IRRIGATION AT EL PASO, TEX., after previous treatment in settling reservoirs and rapid filter beds, has been recommended by Mr. Geo. S. Pierson, M. Am. Soc. C. E., of Kalamazoo, Mich. The use of the crude sewage for irrigation has been tried, apparently in an unsystematic manner, with unsatisfactory results. Mr. Pierson states in his report that the sewage at the mouth of the outlet sewer is too putrid for successful use in irrigation.

IRON IN WATER FROM A FILTER GALLERY at Crookston, Minn., has given so much trouble that artesian wells are being put down for a new source of supply. The filter gallery was put in operation about two years ago. It is located on the bank of the Red Lake River, and is 12 ft. wide, 9 ft. high and 120 ft. long. It was constructed of white pine timber, with 12 × 12-in. mortised bents 5 ft. c. to c., covered on the sides and top with 6 × 6-in. timber. The bottom is left open. The water supply is pumped through the service mains to an elevated tank. Trouble with the iron began as soon as the gallery was put in use. The water is clear until exposed to the air, whereupon "it turns rust color and does not look inviting." The gallery was designed by Mr. J. T. Fanning, M. Am. Soc. C. E., of Minneapolis. For the above information we are indebted to Mr. Ed. Peterson, Superintendent of the Crookston Water-Works, Power & Light Co., who stated that the first artesian well would be completed about July 1, and that as soon as sufficient well water is obtained the gallery will be abandoned. At present some water from the filter gallery, diluted with water direct from the river, is being used.

AUTOMATIC ELECTRO-GAS BLOCK SIGNALS are to be installed on the Putnam Division of the New York Central & Hudson River R. R. This division extends from 155th St. in New York city to Yonkers, N. Y., and the contract for its equipment has been awarded to the Hall Signal Co., of New York city. In this system the semaphore arms are positively held by gravity to a horizontal position to indicate to the engineer danger ahead, or are drawn down to indicate safety by carbonic acid gas pressure in a cylinder in each signal post. The gas is stored in liquid form in a tank underground beside the post. The valve controlling the flow of gas from the tank to the cylinder is closed or released by an electric current passing through the rails, and this is done automatically by the presence of a train in the block ahead, and the approach of a train from behind. The electric connections are such that the signal blade stands normally at danger. When the locomotive approaches it the engineer sees the blade down at safety if it is safe to go ahead, or the blade remains up at danger if there is a train, open switch or a broken rail ahead.

THE ART PALACES for the St. Louis Exposition are to be built by the Goldie Construction Co., of Chicago, under a contract just awarded for $945,127. The Art Palaces will have a total frontage of 836 ft., with the middle building 340 × 166 ft., of fireproof construction. The two temporary art pavilions will each be 200 × 422 ft., separated 44 ft. from the middle building. The Sundry Civil Appropriations bill, approved by the President on June 25, appropriates for the St. Louis Exposition $880,000 for government exhibits, $200,000 for buildings, $40,000 for an Indian exhibit and $8,000 for Life Saving Service exhibitions. Including an appropriation of $5,000,000 for the general fund, the total appropriations by the government to the Exposition amount to $6,308,000.

THE COMMERCIAL CABLE CO., which proposes to have a Pacific cable in working order to Honolulu by Nov. 1, 1902, promises to have a cable to the Philippines in operation by Jan. 1, 1904, provided it can secure certain government assistance. This latter is the placing at its disposal the soundings across the Pacific made by the U. S. government. These soundings would save the time and expense of making a new set of soundings independently. The government is inclined to ask some substantial concession in return for this data, and negotiations to that end are in progress.

A LABRADOR EXPLORATION PARTY, under Col. Willard Glazier, of Albany, N. Y., left Boston on July 1 to explore the practically unknown interior of this territory. It is proposed to ascend the Grand River to its junction with the Northwest River, and to finally reach the main watershed. From the latter point the party will descend one of the rivers emptying on the east coast of the peninsula. The party is largely made up of men from New England colleges; among them are Mr. George H. Clark, of the Peary Expedition of 1893; Mr. Chas. M. Donohoe, of Tufts College, is the civil and mining engineer; Mr. Robert B. Bellamy, of Trinity College, is to attend to the geology and ornithology; Mr. Wm. P. Bates, of Brown University, will also report on the geological and topographical conditions found. Others will pay attention to the mineralogy, meteorology, natural history, etc.

A COTTON MILL OF 500,000 SPINDLES is to be built in Kansas City, Mo., according to plans now made public, and provided that the necessary capital of $10,000,000 can be raised. The prospectus calls for the largest cotton mill in the world, with 12,000 looms and all the necessary machinery for making plain sheeting of various grades. The mill would consume 170,000 500-lb. bales of cotton per year, and would turn out about 75,000,000 lbs. of finished cotton cloth. Large economies are claimed in the location, in direct trade with Western jobbers. Mr. W. B. Smith-Whaley, president of the Olympia and Granby mills of Columbia, S. C., is mentioned as the president and executive manager of the new concern.

UNIT PRESSURES ON LOCOMOTIVE AXLE BEARings are compared for American and Prussian practice in a recent number of the "Organ für die Fortschritte des Eisenbahnwesens" in connection with a general review of American locomotive practice. The article states:

For the axle bearings the Americans use mainly phosphor bronzes. These seem to have two important disadvantages, they run hot comparatively easily by rubbing against the (cast-steel) hubs, and they apparently will stand only low unit pressures. This last would appear, at least, from the large diameters and lengths of the bearings used. Journals proportioned for higher unit pressures than 13 kg. per sq. cm. (185 lbs. per sq. in) are rare in American practice. Comparing with these the Prussian types, we find bearing pressures of 16 to 18 kg. per sq. cm. (228 to 256 lbs. per sq. in.). In this service brass bearings lined with babbitt have given complete satisfaction. Certain (specified) tender bearings have pressures up to 26.6 kg. per sq. cm. (380 lbs. per sq. in.), but these show a tendency to running hot; however, certain (specified) other tender bearings with a maximum unit pressure of 21.6 kg. per sq. cm. (308 lbs. per sq. in.) give no trouble whatever. Of course, a babbitt for such service must be very carefully made. The Prussian railway shops use the following process: 2 kg. antimony are added to 1 kg. melted copper, and to the fused mixture is added 6 kg. pure tin. The mixture is cast into thin plates, and 9 kg. of this metal is melted with 9 kg. pure tin; the mixture is cast into plates 12 to 15 mm. thick. Special stress is laid on using pure ingredients and on performing the mixing in quantities no larger than specified above.

THE TABEAUD HIGH EARTH DAM, NEAR JACKSON, CAL.

The Tabeaud Dam, a new structure, located near Jackson, Cal., is the latest claimant for a foremost place among the high earth dams of the world. The crest of this dam is 123 ft. above the natural surface of the ground at the foot of the lower slope, and 120 ft. above rock vertically beneath the crest. The high water level of the reservoir is 8 ft. below the crest, or 115 ft. above the intersection of the lower slope and the natural ground surface. The inner toe is 100 ft. below the crest, thus giving a maximum water depth of 92 ft.

The San Leandro Dam, which forms a part of the water supply of Oakland, Cal., has a maximum height of 125 ft. above the bed of the stream.*

In our issue of Feb. 20, 1902, we described the Druid Lake Dam of the Baltimore water-works, which has a height from crest to rock foundation of 118 ft. 8 ins.; from the crest to the natural ground surface at the lowest point of the lower slope, 100.33 ft.; and a difference of 95.33 ft. between the latter point and the full reservoir. The Druid Lake Dam was built in 1864-70 and the San Leandro Dam in 1874-5. The Tabeaud Dam was built in 1900-1. The dam itself was completed on Dec. 14 of the latter year, but there was some finishing work on the outlet tunnel and spillway still undone on that date.

The Tabeaud Dam was built by the Standard Electric Company of California as a part of its hydraulic electrical power development. The dam is located on a small tributary of the South Fork of Jackson Creek, about eight miles above Jackson, the county seat of Amador Co. The dam is about 2,000 ft. above sea level and 1,250 above and 1½ miles from the company's power house, on the Mokelumne River, at Electra.

Work on the dam was begun in March and continued until May 15, 1900, under Mr. C. H. Ellison as general manager of the company. On the latter date Mr. Burr Bassell, now of 130 Ellis St., San Francisco, Cal., became engineer-in-charge, and continued in that position until the dam was completed. Our description of the dam has been prepared from Mr. Bassell's final manuscript report and from numerous blue-prints and photographs, all of which Mr. Bassell kindly placed at our disposal.

A general plan of the dam and reservoir, with the outlet tunnel and spillway, is shown by Fig. 1. A more detailed plan of the dam alone is given in Fig. 2, while Fig. 3 shows a cross-section and longitudinal section, and Fig. 11 is a view of the completed structure.

*Schuyler's "Reservoirs for Irrigation," etc., gives the height as 120 ft., but information secured for this Journal by Mr. Bassell shows a height of 125 ft.

The dam has a crest length of 636 ft. and varies from 50 to 100 ft. in length at the base. It is 20 ft. wide at the top and 620 ft. wide at the bottom. Its height has already been given. The total volume of the structure is 370,350 cu. yds., and its weight is about 665,000 tons. The reservoir has an available estimated capacity of 55,000,000 cu. ft., or over 400,000,000 gallons, and the silt capacity below the outlet tunnel is given as 1,091,000 cu. ft. The water surface has an estimated area of 40 acres, and the tributary drainage area is about two square miles. The high water surface is at Elev. 1,250, or 70 ft. above the outlet tunnel.

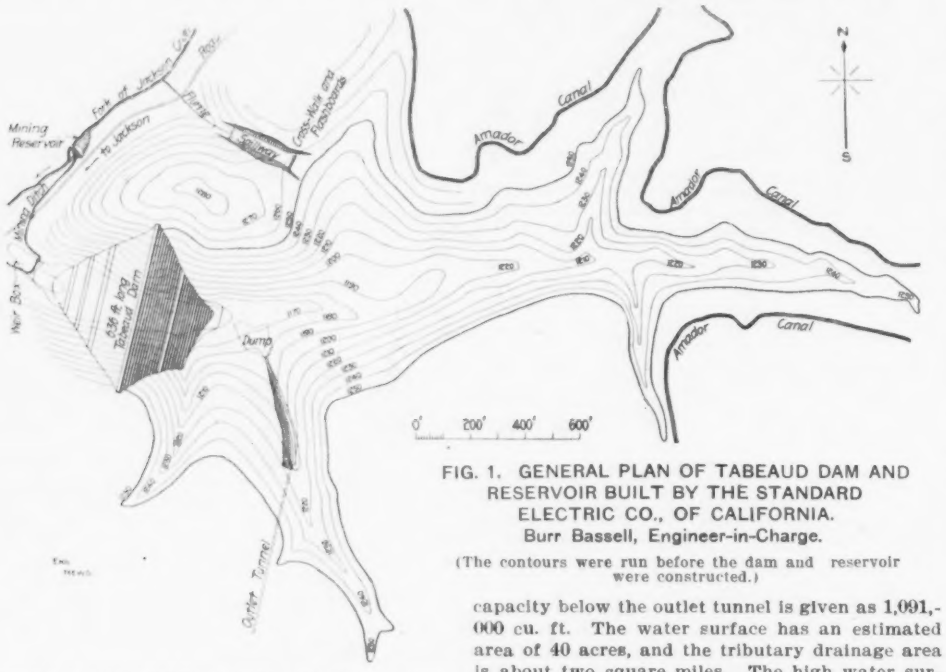


FIG. 1. GENERAL PLAN OF TABEAUD DAM AND RESERVOIR BUILT BY THE STANDARD ELECTRIC CO., OF CALIFORNIA.
Burr Bassell, Engineer-in-Charge.
(The contours were run before the dam and reservoir were constructed.)

As is shown by Fig. 3, the slopes are 2½ on 1, with a rock-fill face of 3 on 1 on the lower part of the inner slope. Beneath the rock-fill there is a heavy facing of puddle and above the upper line of the rock-fill the slope will be paved. The dam was designed to have a puddle heart-wall for its whole length, 8 ft. thick at the top and increasing in thickness towards the bottom. A portion of this was built, as shown in Fig. 3, but it was discontinued after it had reached a height of [illegible] ft.

Progress on the dam was very slow for [illegible] a year, as may be seen by referring to Figs. 2 and 3. On April 15, 1901, Mr. E. B. Stone, of Oakland, Cal., began work under a contract to complete the dam and outlet tunnel by Nov. 1, 1901.

Most of the dam rests on firm hardpan and no balance on rock. The excavation extended to rock beneath both the axis of the dam and near the foot of the inner slope where the puddle face would abutted against the hillsides. Nearly all the bed rock is of slate, with a dip of some 40° up-stream and a strike of 15° with the center line of the dam. About 150 ft. above the center line a quartz vein crosses the valley, on the line F B T. Between this line and the longitudinal axis the rock was satisfactory, but above the quartz vein fissures and springs were found. The principal springs were at the points marked F, E, T, R, K, M and S, Fig. 2.

FOUNDATION DRAINAGE.

To remove this spring water, and to intercept seepage beneath the whole length of the dam, a system of bedrock drainage was constructed, as shown in plan and section by Figs. 2 and 3, and in detail by Fig. 4. The view, Fig. 5, shows the rock trenches for the upper end of the drainage system as far down as the point A in the plan, Fig. 2. Various lengths of this same portion of the drainage system are shown under construction by Figs. 6 to 8.

The water from the springs F, E and T, Fig. 2, is led to the point N through the space between the concrete layer in the trench and the inverted V-flume. At the small chamber N this water enters a 2-in. pipe, laid within the space formed by the flume, and is conveyed down stream to P, where the rear drain begins. Water from the springs R, K, S and M, Fig. 2, is likewise led to N, but during construction wells were maintained at S and K and a stand-pipe at J. The latter was carried up through the embankment, and was ultimately filled with cement, the branch pipes capped at their upper ends and the wells, or sumps, filled with broken stone.

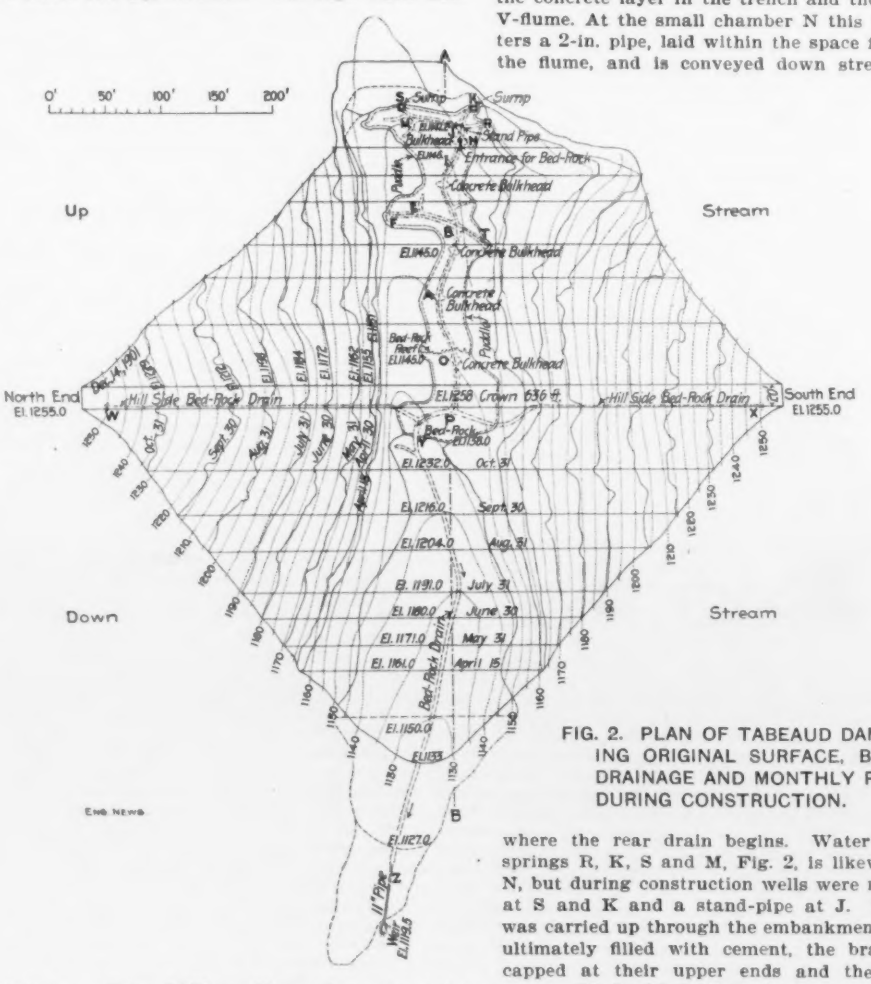


FIG. 2. PLAN OF TABEAUD DAM, SHOWING ORIGINAL SURFACE, BED ROCK DRAINAGE AND MONTHLY PROGRESS DURING CONSTRUCTION.

The concrete used to fill the trenches was 1 : 1 : 3, and the cement mortar was 1 : 1, Portland cement being used in both cases. Above the concrete and over the area of the bedrock foundation

included between the dotted lines shown in Fig. 2 clay puddle was placed.

The hill side drains were located approximately parallel with and 8 ft. below the longitudinal axis of the dam, and were carried to Elev. 1,250. The trench, Fig. 4, ranged in width from 5 to 10 ft. and extended varying distances into the rock, according to the character of the latter. The

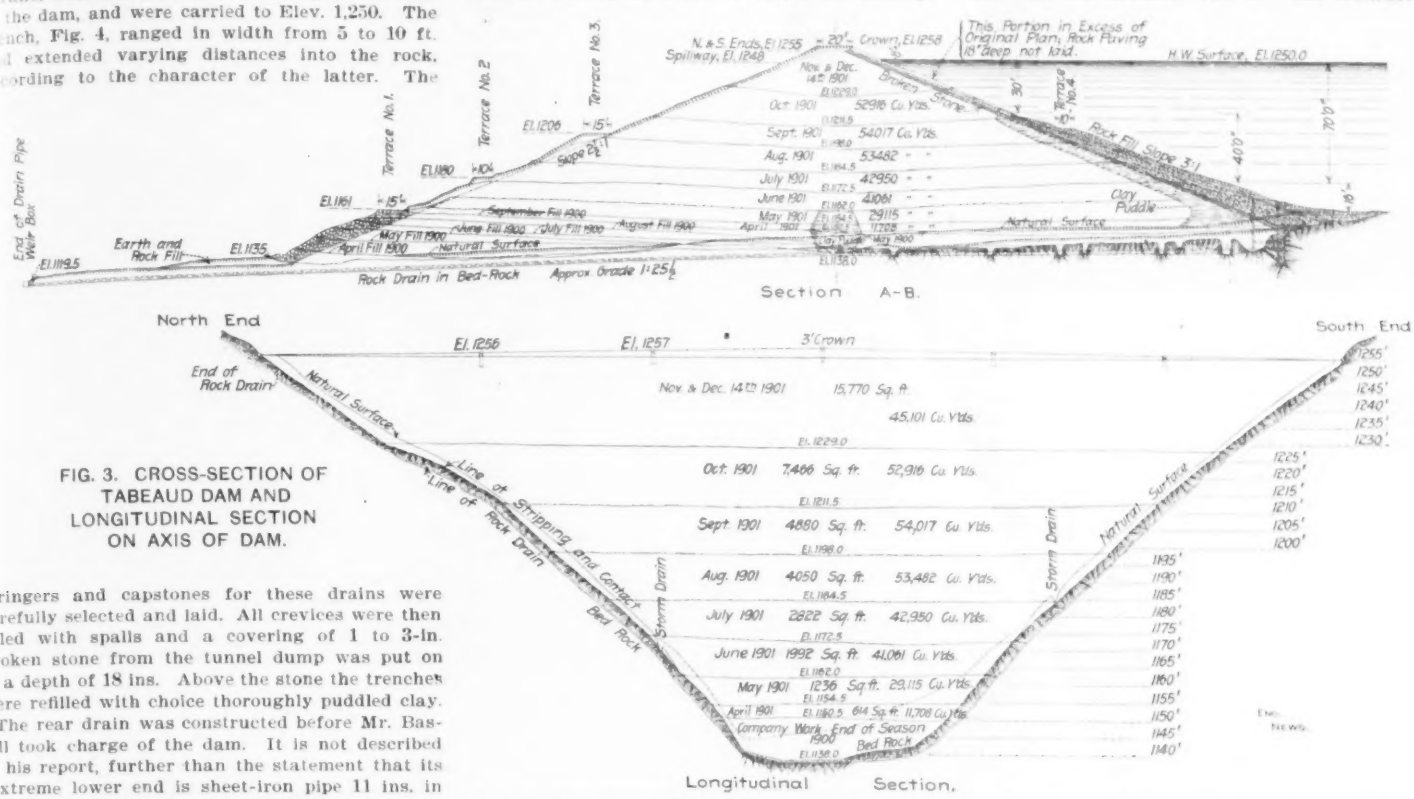


FIG. 3. CROSS-SECTION OF TABEAUD DAM AND LONGITUDINAL SECTION ON AXIS OF DAM.

stringers and capstones for these drains were carefully selected and laid. All crevices were then filled with spalls and a covering of 1 to 3-in. broken stone from the tunnel dump was put on to a depth of 18 ins. Above the stone the trenches were refilled with choice thoroughly puddled clay.

The rear drain was constructed before Mr. Bassell took charge of the dam. It is not described in his report, further than the statement that its "extreme lower end is sheet-iron pipe 11 ins. in diameter, the exact length of which is unknown." Mr. Bassell adds that this pipe "will doubtless rust away in time and need to be replaced," and

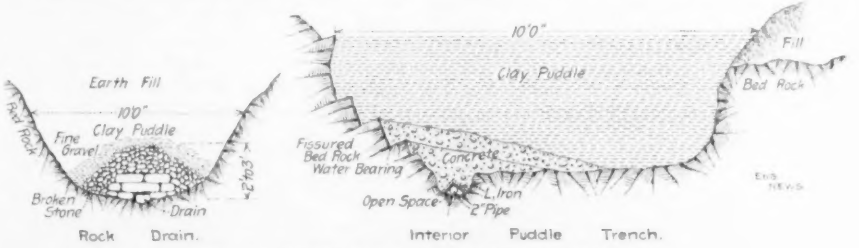


FIG. 4. DETAILS OF FOUNDATION DRAINAGE.

urges the importance of keeping the rear slope and outer toe of the dam well drained.

Observations at a small weir at the outlet of the drain indicate a quite constant seepage of about 13 gallons per min. The maximum discharge has

Fig. 5. Trenches for Bed Rock Drainage Beneath Upper Central Portion of Dam.

(Looking southeast. The general elevation of the main rock surface is 1,143.)

been 180 gallons per min. during a heavy rainstorm.

The foundation drainage system served the important function of removing nearly all the water from the works until the wells S and K, Fig. 2, and their outlet pipes were closed. A 4-in. centrifugal pump was then used to take care of the storm water and the drainage from the outlet tunnel. During the winter of 1900-1 the drainage system was supplemented by temporary ditches around the ends of the embankments. A heavy rainfall in November, 1900, flooded the "basin of the embankment" to Elev. 1,155 and covered the mouth of the inlet to the drains to a depth of 5 ft.

BUILDING THE EMBANKMENT.

The material for the dam was all obtained close at hand. The earth was taken from borrow pits within the reservoir basin at the sides of the reservoir and at the ends of the dam. Most of the

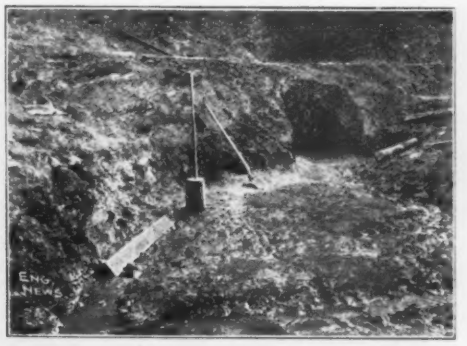


Fig. 6. Trench from Spring T, Fig. 2, Filled with Concrete to Bottom Level of Inverted V-Flume.

rock-fill facing came from the tunnel dump and the balance from quarries in a ravine to the south of the dam. It was hauled in carts and stick-wagons. The company built only 40,000 of the 370,350 cu. yds. of bulk of the dam. It had a small steam shovel and some cars on the ground, but the extent to which it used these is not stated.

The contractor used a larger steam shovel, of 1½ cu. yds. capacity, for about a month, but it mixed so much stone with the dirt that the engineer was not satisfied with it. The contractor used the buck or drag-scraper of the "Fresno pattern" to bring the earth from the borrow pits to a loading platform, or trap, consisting of a timber platform, with hole about 20 × 40 ins., through which the wagons were filled. With good material, eight of these scrapers could fill an average of 25 wagons per hour. The patent dump wagons had a capacity of 3 cu. yds. and could be dumped by the driver while the wagons were in motion through two trap doors. The average haul for the entire earth work was about one-fourth mile.

The maximum equipment of the contractor was as follows: One 1½-yd. steam shovel; 37 dump wagons; 11 rock wagons and carts; 39 Fresno scrapers; 21 wheel scrapers; 8 road and hillside ploughs; 3 road graders; 3 sprinkling wagons; 2 harrows; 2 rollers (5 and 8-ton); 233 men; 416 horses and mules. The wheel scrapers were used but little.

The embankment was founded on hardpan or rock, as already described. Vertical steps were

Fig. 7. North Trench, or E F, Fig. 2, Showing Angle-Iron Ready to Cover with Concrete and Puddle.

(Impervious rock is shown on the left and fissured rock at the right of that.)

avoided, and the cuts were generally large enough for horses to turn in, thus enabling their use, instead of hand tamping, on the puddling work. The stripped surfaces were wet by means of hose

Fig. 8. Main Trench, with Springs R and K, Fig. 2, in Distance, and with V-Flume and 2-in. Pipe in Place.

and nozzles before the embankment was started.

The earth was dumped in rows, generally parallel with the longitudinal axis of the dam, and ranged from the axis towards the slopes. At the ends of the dam a few rows were frequently made parallel to the intersection of the embankment and the hillside. The best material was placed at the ends and on the up-stream half of the dam. The top surface was kept basin-shaped, giving a slope of about 1 on 25 from the sides to the center. The puddle heart-wall was discontinued at Elev. 1,160 and more attention given thereafter to the puddle on the inner face. This change from the original plan was made by Mr. Bassell, soon after the contractor began his work, because of the character of the material available, and the excellent results obtained in securing an homogeneous earthen-concrete, practically impervious. Besides, the central puddle wall would have greatly interfered with the progress of the work and delayed the completion of the dam.

The central section of the embankment, however, received more water than other portions which were not strictly puddle, on account of the basin shape and manner of wetting. Any excess of water in this portion would be readily taken care of by the cross-drains.

The contract specifications provided that the puddling material should contain about 70% of clay and about 30% of gravel less than 2 ins. in diameter.

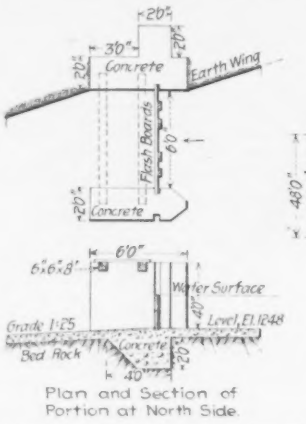
Rock-pickers and carts followed the dumping wagons, removing all roots and all stones which would not pass through a 4-in. ring. The specifications provided that no stone weighing over 5 lbs. should be allowed in the dam, and that "layers of rocky material must alternate with layers comparatively free from rock." All the waste was dumped outside the slope line, after which the roots were burned.

Six-horse road-graders leveled down the rows of dirt and were followed, in turn, by harrows and rollers, with sprinklers interspersed, as was found necessary. By properly spacing the dirt loads and rows, layers of any desired thickness could be secured, while the graders made as smooth and uniformly thick a layer as could be asked. If the material was dry, it was sprinkled as soon as the graders had given it a general leveling; otherwise there was no sprinkling until between the harrowing and rolling, and some of the time none was necessary then. The previous layer, however, was always sprinkled before a new one was added, and hose with nozzles were almost constantly employed for wetting down the outer slopes, the stripped hillsides and all points which the wagons could not reach.

One of the two rollers weighed 5 tons and had a 60-in. face, giving 166 lbs. per lin. in.; the other one weighed 8 tons and had a 40-in. face, thus giving 200 lbs. per in. The rollers were not grooved, but the loaded wagons passing over the layers cut the surface to a greater or less extent. The loaded wagons weighed over 6 tons apiece, or 750 lbs. per lin. in. of wheel tread. They were made to travel where they would do the most good, particularly near the edge of the inner slope and along the ends of the embankment where it joined the hillside. Generally the rollers were drawn lengthwise of the dam, but they frequently went crosswise at the ends and also round and round a portion of the surface. The contract specifications stipulated that each 100 cu. yds. of material should be rolled one hour, or compressed to an equivalent amount, and that the compression should be sufficient to prevent quaking when a loaded wagon passed over the layer.

The specifications provided that for the first 60 ft., or to Elev. 1,220, the layers should not exceed 6 ins., and above that level 8 ins. in thickness. The average thickness of the finished layers under the contract work was as follows: April, 4 ins.; May, 3½; June, 4; July, 4½; August, 5; September, 6; October, 7; November and December, 8.

Tests of the material used in building the dam, made in June and September, 1901, showed the following average weights of 1 cu. ft. of material under different conditions: Dust dry soil, 84 lbs.; fully saturated, 101.7; natural bank, 116.5; delivered from wagons, moist and loose, 76.6; loose dirt from dam, shaken down and measure struck, 80; test pits in dam, 133 lbs. The dirt from the test pits in the dam contained 38% of gravel and grit. The natural soil had 19% of moisture; 33% of water had to be added to it for saturation. The voids were 52% of the total. The angle of repose of the moist earth from the bank was 44°; of dirt dry dust, 36°; of saturated dirt, 23%. The cuts at the borrow had vertical sides.



Plan and Section of Portion at North Side.

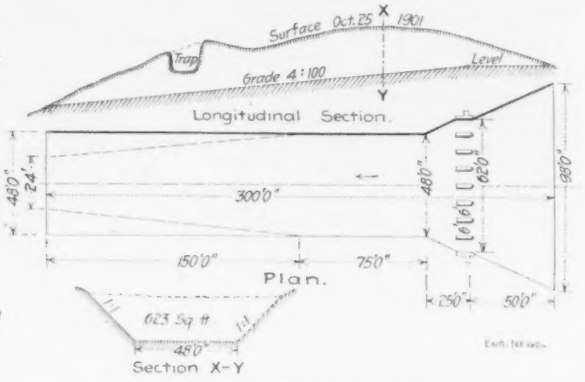


FIG. 12. DETAILS OF SPILLWAY.

THE SPILLWAY.

The spillway, shown in the general plan, Fig. 1, is cut through a hill and discharges into a ravine which joins the main valley 500 ft. below the dam. The cut was finished by the contractor on Dec. 21, 1901. It is 48 ft. wide at the bottom, 300 ft. long, and involved the excavation of 1,700 cu. yds. of earth and 2,072 yds. of rock. Up to the date of Mr. Bassell's report, Jan. 24, 1902, it appears that cutting the channel just described was the only work on the spillway which had been done. The report stated that the cut would need to be concreted, on account of the softness of the rock, and that the normal flow of waste water should be carried in a flume, as shown by Fig. 1. A design for 2-ft. flash boards, to be placed in eight 6-ft. openings, is shown by Fig. 11. These would maintain the water surface at Elev. 1,250.

THE OUTLET TUNNEL.

The outlet from the reservoir is a tunnel 2,900 ft. long, through the ridge between the Jackson Creek and Mokelumne drainage areas. At the reservoir end the tunnel is reached by an open cut 350 ft. long, and at the other end by one 330 ft. long, each cut having a maximum depth of about 26 ft. The tunnel has a sectional area of about 40 ft. It is 6 ft. wide and 7 ft. high, the upper 3 ft. having a semicircular section. It "pierces a solid slate formation, which was found generally to be very hard and satisfactory." The tunnel was begun before Mr. Bassell took charge, and was prosecuted with no machine work at the

FIG. 9. VIEW OF TABEAUD DAM UNDER CONSTRUCTION.

(Taken Sept. 27, 1901, when the main embankment was approximately at Elev. 1210, or 72 ft. above the foundation.)

reservoir end and but very little at the other end, until the contractor took up the work on April 15, 1901. The tunnel had then been driven 600 ft. at the reservoir end and 654 ft. at the other end. The company installed a new Ingersoll-Sergeant air compressor for the contractor at each end, and with this new equipment work was begun early in May. The men worked in three eight-hour shifts, with one machine drill at each face.

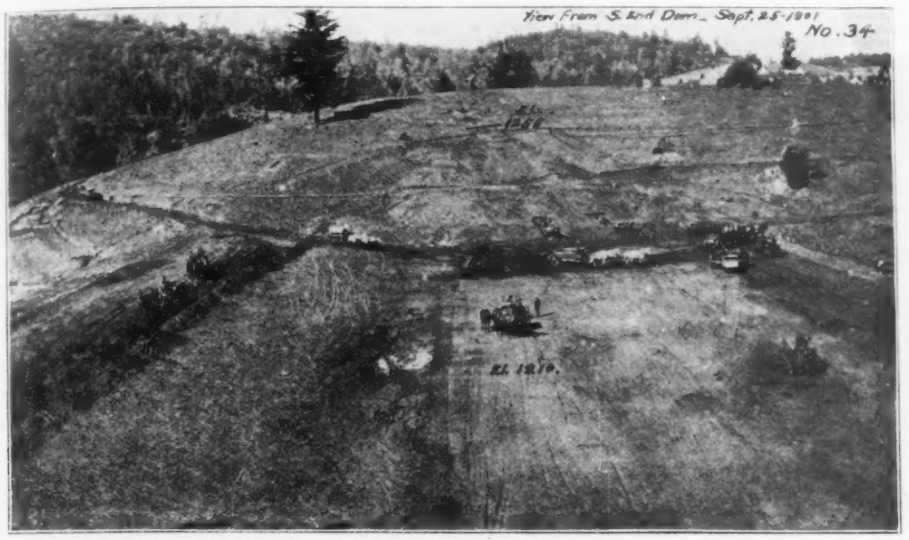


FIG. 10. VIEW OF DAM UNDER CONSTRUCTION, TAKEN ABOUT THE SAME TIME AS FIG. 9. (One Roller just finishing a section.)

On Nov. 30, 1901, the headings met. The engineer's alinement met within 3/8-in. and the grade within 7/8-in. Mr. Bassell recommends that certain weak lengths, amounting to about 180 ft., be lined with cement concrete.

Some other recommendations made by the engineer in his final report were as follows:

That the reservoir be not filled above Elev. 1,220, or 40 ft. over the tunnel, until the dam has stood a year or so and the hand-laid rock facing above Elev. 1,220 has been laid, as called for by the original plans; that the down-stream slope be sodded with Bermuda grass or else planted with native pines, preferably the latter; that the levels of the crest of the dam be taken at intervals of, say, three months for five or ten years; and that rainfall and evaporation records be kept.

Mr. C. H. Ellison laid out the work and superintended its construction from early in March until May 15, 1900. On the latter date Mr. Bassell took engineering charge of the work and prepared plans and drawings. Mr. W. R. Eckart, M. Am. Soc. C. E., of San Francisco, Cal., is consulting engineer to the company.

In August, 1901, when the dam was well towards completion, some adverse criticisms from an engineer who had visited the work reached Mr. Bassell, whereupon he requested an investigation. At Mr. Eckart's recommendation, the company selected Mr. Jas. D. Schuyler, M. Am. Soc. C. E., of Los Angeles, to examine the work. Mr. Schuyler visited the dam on Sept. 1, 1901. Mr. Bassell states in his report that while by implication Mr. Schuyler gave the work "a measure of criticism," nevertheless he saw "fit to say of it:"

That the construction of the dam was being carried on in a manner entirely in accordance with the best engineering practice. The materials are carefully selected, properly manipulated and compacted in a way to produce absolute water-tightness in the body of the embankment and a minimum amount of future settlement.

(Finally) That no proper precaution had been omitted to render the dam stable, water-tight and secure. That, from his general investigation of the plan, and the history of the work, there was no cause for apprehension of the safety of the dam when put into service, provided all proper precautions in construction be observed henceforth. Some leakage may be expected through the bed rock around the dam, but this leakage should be without danger to the stability of the structure.

Speaking of the hillside drains, Mr. Schuyler says:

. . . . . they serve a useful purpose during construction in drying off the surface of the dam after rains, and when the dam is completed and filled, they will give vent to any seepage water that may creep along the line of contact between the dam proper and the hillside.

The saturation of the outer slope of the dam by further creeping along the line of contact should thus be prevented, and the integrity of the outer half be preserved. Water cannot pass out of these drains into the body of the dam because of the fine character of the puddle with which they are covered. Hence they should act for ever as efficient safeguards.

Mr. Schuyler also bore the following testimony regarding the manner in which the successive layers of the embankment were united:

The test-pits showed that there was no distinct line traceable between layers, and no loose or dry spots, but the whole mass was solid and homogeneous.

No figures of cost were given in Mr. Bassell's report. In a recent letter to this journal, Mr. Bassell gives the following general information on the subject:

The more tedious work of excavating and draining the foundation, including refilling with puddle, was done by the company, and at a disadvantage. A fair average statement of cost for this portion of the work would be 55 cts. per cu. yd. each for excavation and for puddle.

The portion done under contract, that of constructing the dam upon the foundation already prepared, was comparatively easy, and may be put at 40 cts. per. cu. yd., measured in the completed structure, as stipulated by the contract. The specifications, contract and drawings were all prepared by myself, and permit me to say in this connection, that I believe it better, for several reasons, to pay for such contract work in the completed structure rather than by measurements at the borrow pits.

FIG. 11. VIEW OF TABEAUD DAM TAKEN ON THE DAY OF ITS COMPLETION.

WIDENING THE GAGE OF THE BURLINGTON & NORTHWESTERN RY. AND BURLINGTON & WESTERN RY.

The few remaining railways of 3-ft. gage are gradually being widened to standard gage, especially where these lines form part of standard gage railway systems. One of the most important changes of gage of this kind was accomplished on Sunday, June 29, on the lines of the Burlington & Northwestern Ry. and Burlington & Western Ry., both of which are included in the Burlington System, and aggregate about 125 miles in length.

The Burlington & Northwestern Ry. extends from Burlington to Washington, Ia., 52.3 miles, and was built about 25 years ago by an independent company. Some of the stockholders of the Burlington System (C., B. & Q. Ry.) became interested in the Burlington & Northwestern Ry., and a few years later built the Burlington & Western Ry., from Winfield (on the B. & N. W. Ry.), to Oskaloosa, Ia., 70.8 miles, for the purpose of protecting territory then being invaded by a construction company which was building the Iowa Central Ry. It was recently decided to convert these two lines from 3-ft. gage to the standard gage of 4 ft. 8½ ins., and also to extend the Burlington & Western Ry. to Tracey, Ia., where it will connect with the Albia Branch of the Chicago, Burlington & Quincy Ry.

For particulars of the work of changing the gage we are indebted to Mr. R. Law, of Burlington, Ia., who is Manager of the two roads. About eight years ago, when he took charge of these lines, work was commenced in improving the roadbed and substituting standard gage material for the light narrow gage material by degrees, as the earnings of the property would justify. The track is now laid with 56 to 66-lb. steel rails and fastenings, substituted for the original 28 to 35-lb. iron rails; there are also standard ties and standard bridges (some of them metal structures), and the station buildings have been lowered and moved back and the platforms widened.

About two weeks before the change of gage, preparations were begun by adzing the ties, to form rail seats to receive the rails when moved out. This was done by a temporary machine consisting of several saws on either side of narrow gage tracks, the saws being driven at a high rate of speed by power from a portable engine on a flat car, which was moved along at the rate of 12 to 15 miles a day by a locomotive. A machine of this kind designed and built by Mr. G. M. Brown, formerly Chief Engineer of the Pere Marquette R. R., was illustrated in our issue of Nov. 30, 1899. After this had been done, the outside spikes for standard gage were driven, and all the inside spikes of the narrow gage track, except five or six to the rail, were drawn by repairmen. All sidetracks which included switches and frogs necessary for the proper conduct of the business were changed by the same gangs and at the same time as the main line. Other less important sidings were left to be widened within a day or two afterwards. The widening was effected by moving both rails outward 10¼ ins. from their original positions.

It was arranged to employ about 400 section men for this occasion from adjacent lines; the Chicago, Burlington & Quincy Ry. and the Chicago, Rock Island & Pacific Ry. Narrow gage trains with sufficient cars to accommodate the force were started from Burlington, Oscaloosa and

Washington between 4.30 and 5 a. m. Sunday morning, June 29, distributing gangs of about 16 men at intervals of four miles. When the narrow gage trains had their men distributed, they were run on sidings, the engines were "killed," and the trains will remain there until the opportunity affords to load them on standard flat cars to take them to Burlington for storage until they are disposed of. Standard gage engines with cars sufficient to carry the men followed and picked them up as their work was completed, delivering them back to the starting points in the evening after the work is finished. The work was completed in about 9 hours.

As there is but little traffic on Sunday it was only necessary to abandon two freight trains and one passenger train. The narrow gage passenger train due to leave Burlington at 3.30 p. m. was about two hours late, and was the first standard gage regular train. No narrow gage equipment will be converted, as first-class standard gage equipment has been purchased from the C., B. & Q. Ry. for these lines. At present the roads are using stub switches, and they will continue to do so for a time, but later on split switches will be substituted.

One important detail was the feeding and care of the men. As the work was confined to the one day, provision for sleeping was unnecessary. The feeding, however, was no small item. Mr. Law states that the company purchased the best of everything; hams, fresh buns, fresh eggs and coffee; and did the work of boiling the hams and eggs and preparing the sandwiches. There were about 6,000 bun sandwiches, 500 dozen eggs and 250 gallons of coffee. These supplies were distributed from the work trains with the men. Each gang was also furnished with a narrow gage hand-car upon which were placed a barrel of ice water and the food, this being moved along with each gang as the work progressed.

BOOK REVIEWS.

HYGIENE AND PUBLIC HEALTH.—By Louis Parkes, M. D., and Henry Kenwood. Philadelphia: P. Blakiston's Son & Co. Cloth, 5½ × 7½ ins.; pp. 732; 85 illustrations. $3.

This standard English work here reaches its sixth edition. It appears to have been so thoroughly revised as to bring it as nearly up to date as can be expected in any scientific treatise. While written particularly "for those members of the medical profession who are studying for the various public health diplomas" granted in England, this volume is eminently useful for American students as well; in fact, it is far better than a number of American books covering the same general ground.

PUBLIC ABATTOIRS AND CATTLE MARKETS.—From the German of Oscar Schwarz, M. D., Director of the Public Slaughterhouse and Cattle Yards, Stolp. Edited by G. T. Harrap, Assoc. M. Inst. C. E., M. Inst. M. E., and Loudon M. Douglas, Assoc. M. Inst. C. E. London: Ice & Cold Storage Publishing Co. Cloth, 6 × 10 ins.; pp. 472; numerous illustrations. $2.50.

The translation of this volume, made in 1901, is based on a revised German edition brought down to August, 1898. The subject is treated in detail, including both a general review of the best practice and descriptions of the slaughterhouses of a number of cities. Cold storage, including ice and refrigeration, is taken up, and there are chapters on sewage purification and manure utilization, the utilization and destruction of unsound meat, cattle markets and market halls. The book appears to fill a gap in technical literature.

IRRIGATION IN THE UNITED STATES.—By Frederick Haynes Newell, M. Am. Soc. C. E., Chief of the Division of Hydrography, U. S. Geological Survey. New York: Thomas Y. Crowell & Co. Cloth; 6 × 8 ins.; pp. 417; 62 plates and 94 figures in the text. $2, net.

The author says that "home-making is the aim of this book." With that end in view he aims to show in a clear and readable manner what irrigation is, something of what it has done for this country and, most of all, what a future it presents both for the individual and for the United States as a whole. The vast area of public lands awaiting reclamation, with special reference to the arid region, is discussed, and maps and diagrams are used to make the situation plainer. Then follows a presentation of such subjects as surface and underground water supplies, stream measurements, reservoirs, canals, small pumping plants, methods of irrigation and irrigation law. Each state in the arid and semi-arid region is reviewed separately, with reference to its topography, climate, water supply and cultural conditions. There is also a general review of irrigation in the humid states. In the closing chapter liberal quotations are made from remarks on irrigation made by President Roosevelt and by the Hon. E. A. Hitchcock, Secretary of Agriculture. It hardly seems necessary to say that Mr. Newell's long and intimate connection with water supply and irrigation studies in the United States qualify him to write just such a book as he has undertaken. The volume deserves a wide circulation, both East and West, but perhaps it is most needed in the East, where there is so much to be learned before the irrigation problem and the national blessings attendant upon its proper solution are appreciated.

A TREATISE ON HYDRAULICS.—By Henry T. Bovey, M. Inst. C. E., Professor of Civil Engineering and Applied Mechanics, McGill University, Montreal. Second Edition, Rewritten. New York: John Wiley & Sons. Cloth, 6 × 9 ins.; pp. 582; tables and 330 figures in the text. $5.

The first edition of this book was well spoken of in our issue of Nov. 21, 1895. To the present edition there have been added 240 pages, including 130 new figures. Of new matter the following may be mentioned: Articles on whirling and rotation of fluids; resumé of Bazin's experiments on weirs; "results of experiments collaborated and tabulated by Mr. C. W. Tutton, of Buffalo," given in the chapter on "Fluid-Friction and Pipe Flow;" new articles on accumulators, presses and water engines; and a new chapter on centrifugal pumps. The book now includes eight chapters, three of which relate to the flow of water, one to rams, hydraulic presses and the like, and the balance to turbines, water wheels and centrifugal pumps.

A TEXT BOOK OF ROOFS AND BRIDGES: Part III., Design.—By Mansfield Merriman and Henry S. Jacoby. New York: John Wiley & Sons; Cloth, 6 × 9 ins.; pp. 374; 149 illustrations; $2.50.

This is a new edition of the well-known work whose title is given above, and little further mention is necessary than to note the additions and changes which have been made in the work. These are given concisely in the preface as follows:

The present edition has been entirely rewritten in order to bring the subject fully up to date, for the changes in bridge design during the past eight years have been remarkable. The rapid increase in live loads on the principal railroads in this country has necessitated an unusually large amount of new construction to replace the old bridges, which were designed for much lighter traffic. The extensive scale on which this work had to be done led to a general revision of specifications and to a careful attention to the design of details so as to secure greater stiffness as well as strength in the new structures. These changes include the introduction of some new forms of details; the elimination, as far as practicable, of adjustable members; the entire superseding of wrought iron by steel; the substitution of riveted trusses for pin-connected trusses in the shorter spans; and increased care in designing the joints so as to reduce the secondary stresses to a minimum. In the descriptions of the details of plate-girder and truss bridges, introduced in Chapters VI., VIII. and XI., only those are given which may be properly claimed as standard in the best recent practice. Special attention is called to the new feature of carefully selected references to engineering periodicals where more extended descriptions and applications of various details may be found. The designs in Chapters VII., IX. and X. are new, being made in accordance with the latest specifications and most approved practice.

HANDBOOK FOR STREET RAILWAY ENGINEERS.—Containing Geometrical and Trigonometrical Formulæ, Transition Curve Tables, Track Construction Tables, Strength of Wooden Beams and Columns, Electrical Formulæ and Tables, and Much Other Information Invaluable in Street Railway Design and Maintenance. By H. B. Andrews, C. E. Boston, 1902. New York: John Wiley & Sons. Flexible leather, 3 × 5 ins.; pp. 199; illustrated. $1.25.

This promises to be a very handy and useful book for the purpose set forth in the title. The greater number of the tables included and the practice recommended are thoroughly up to date, and the tables are selected with excellent judgment, as being those most useful to the modern street railway engineer. Transition curves are very fully treated and these are based on a system prepared by the author under the direction of Mr. A. L. Plimpton, Engineer for Surface Lines of the Boston Elevated Railway Co. Track-construction tables separately deal with weights and cost of rails, joints and bolts, tie rods and plates, spikes, rail-bonding, paving, labor and earthwork. Electrical information occupies considerable space, and includes many tables, discussions on power and resistance, copper calculations, aluminum for electrical conductors, railway storage batteries, etc. At the end is an original table giving average percentages of the expenditures to the gross incomes of all the street railways of Massachusetts, separated into the detailed items and aggregated under general heads.

THE MECHANICAL INDEX.—Section A, Machine Tools and Metal Working Machinery. New York: The Industrial Press. Paper, 6 × 9 ins.; pp. 136. $1.

This is Part I. of a publication which is eventually to be issued in book form, to contain about 600 pages and to give a complete classified directory of the manufacturers of mechanical appliances in the United States. The present section covers only makers of machine tools and metal working machinery, and future sections will cover wood-working machinery, electrical appliances, steam appliances, etc. We have heard of engineers recently who are going to large expense in the matter of filing and classifying trade catalogues, and to such engineers it appears to us that a work of this sort would be of great assistance and worth all it cost.

Judging by the part before us, much labor and pains have been devoted to the work of classifying and arranging, but the classification adopted appears to us exceedingly faulty. For example, there is a separate department for "Machine Tools," and another for "Metal Working Machinery." Where the compiler draws the line between these two classes it has puzzled us to tell. We do not see why any "machine tool" is not also "metal working machinery," or why most metal working machines are not machine tools. The compiler of this work, however, evidently knows just where to draw the line. Lathes and planers and grinding and milling machines in his mind are "machine tools," while punches and shears and riveters and presses of all sorts are "metal-working machinery." Plate planers he also puts under metal working machinery, and likewise power saws of all sorts for cutting metal, while "sawing machines" are put under machine tools! Bending machines he classes as metal working machinery, while a straightening machine is a machine tool. As an example of a still finer distinction: Profiling machines are "metal working machinery," while shapers are "machine tools."

We cannot regard this as by any means a minor defect. The usefulness of any such work depends on the intelligent and systematic classification of its contents. There are plenty of poor indexes of this sort published, and some of them are distributed gratis. If the publishers of this volume wish to make their work valuable and worth its cost to the users, they must remedy such obvious defects before issuing it in complete form.

COMPRESSED AIR.—Its Production, Uses and Applications Comprising the Physical Properties of Air from a Vacuum to its Liquid State, its Thermodynamics, Compression, Transmission and Uses as a Motive Power in the Operation of Stationary and Portable Machinery, in Mining, Air Tools, Air Lifts, Pumping of Water, Acids and Oils; the Air Blast for Cleaning and Painting, the Sand Blast and Its Work, and the Numerous Appliances in Which Compressed Air is a Most Convenient and Economical Transmitter of Power for Mechanical Work, Railway Propulsion, Refrigeration and the Various Uses to Which Compressed Air has been Applied. By Gardner D. Hiscox, M. E. New York: Norman W. Henly & Co. Cloth, 6½ × 9¾ ins.; pp. 852; 545 illustrations. $5.

Engineers who are familiar with the author's previous book on gasoline engines have a very fair standard with which to measure the technical qualities of this bulky volume. It is a compilation of all sorts of information from all sorts of sources presented in the semi-popular, semi-technical manner usual to the "trade" paper. Much of the information is of value, since, where everything is preserved, the good endures as well as the bad; more of it is merely interesting.

Except for the merit of being gathered into a single volume, which it possesses, none of the information is better presented than it was in the original books, papers and trade catalogues, from which it was taken, and much of it, particularly that which relates to the thermo-dynamics of compressed air production and use, is much better handled in other and cheaper books, which are available to the engineer. The feature in which the engineer will find the book of particular value is its concise enumeration of the multitude of uses to which compressed air is put and its description of the tools and appliances employed in these uses. These portions of the book are well and clearly written and elaborately illustrated, and as they comprise the great bulk of the book, the author has done good work in bringing them together in convenient form in one place.

ANNUAL MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

The annual meeting of this Association was held in Pittsburg June 30 to July 3, inclusive. During the same week meetings of several affiliated societies were also held. These are the Geological Society of America, the American Chemical Society, Society for the Promotion of Agricultural Science, Botanical Society of America, American Microscopical Society, American Folk-Lore Society, Association of Economical Entomologists, Society for the Promotion of Engineering Education, American Physical Society, American Anthropological Association and National Geographic Society. Hotel headquarters were at the Hotel Schenley, and the meetings were held in the Carnegie Institute and in some of the church and school buildings in the immediate neighborhood. The registered attendance of members and guests of the Association was rather disappointing, the printed list on July 3 showing only 431 names, of which about 70 were residents of Pittsburg and vicinity. A most elaborate program of entertainment was afforded, including visits to works, steamboat excursions, lawn parties and popular lectures. The Association met in general session a short time each morning, as usual, and then separated into the various sections, viz.: A, Mathematics and Astronomy; B, Physics; C, Chemistry; D, Mechanical Science and Engineering; E, Geology and Geography; F, Zoology; G, Botany; H, Anthropology; I, Social and Economic Science. More than 200 papers were read or presented by title in the several sections. Section D had a rather remarkable revival. Two years ago at the New York meeting the members in attendance were so few that they were ready to give up the section, and had a motion presented in the Council for its discontinuance. The Council refused, however, to end the existence of Section D, and at Pittsburg it had an attendance for two

morning of about 40. No less than 23 papers were presented and some of them were discussed at length. The vice-presidential address before this section by Prof. H. S. Jacoby was on "Recent Progress in Bridge Construction." The list of papers is as follows:

1. "The Trend of Progress in Prime Movers;" R. H. Thurston.
2. "Changes in Form as an Essential Consideration in the Theory of Elasticity;" Frank H. Cilley.
3. "On the Advantage of Siamesed Hose Lines for Fire Streamers;" Mansfield Merriman.
4. "The Nomenclature of Mechanics;" R. S. Woodward.
5. "On the Ratio of the Transverse to the Longitudinal Elastic Strain Produced by Longitudinal Stress;" Thomas Gray.
6. "On the Effect of Hardening Steel on Its Young's Modulus;" Thomas Gray.
7. "U. S. Work in the Ohio, Allegheny and Monongahela Rivers, near Pittsburg;" Thomas P. Roberts.
8. "On a Type of Planetary Orrery Using the Mechanical Principle of the Conical Pendulum;" David P. Todd.
9. "The Viscous Dynamometer;" J. Burkitt Webb.
10. "The Dynamophone, a New Dynamometer;" J. Burkitt Webb.
11. "The Deflection of a Complete Quadrilateral;" J. Burkitt Webb.
12. "A Test of a Ball Thrust Bearing;" Thomas Gray.
13. "A New Photometer, with Exhibition of the Instrument;" C. P. Matthews.
14. "The Rules and Regulations Concerning Air-Ship Contests at the Louisiana Purchase Fair;" C. M. Woodward.
15. "New Methods of Experimentation in Aerodynamics;" H. Mattullath and A. F. Zahm.
16. "Long Distance Electric Transmission Regarded as a Hydrodynamic Phenomenon;" H. T. Eddy.
17. "The Effect of Weeds and Moss Upon the Coefficient of Discharge in Small Irrigating Canals;" J. C. Nagle.
18. "The Compound Pendulum;" Albert Kingsbury.
19. "Crushed Steel and Steel Emery, an Artificial Abrasive;" M. M. Kann.
20. "The Mechanics of Reinforced Concrete Beams;" W. K. Hatt.
21. "Some Experiences with a Simple Babbitt Testing-Machine;" E. S. Farwell.
22. "Notes on the Electrical and Mechanical Equipment at the Charleston Exposition;" J. H. Granberry.
23. "Determination of the Exponent in the Equation $p v^n$ = c of Heat Engine Indicator Diagrams;" W. T. Magruder.

Opportunities for visiting many of the industrial works of Pittsburg were afforded to the members of section D, and visits were made to the Homestead and Duquesne steel works, the works of the Pressed Steel Car Co., Westinghouse Electric & Mfg. Co., Westinghouse Machine Co. and the Davis Island Dam below Pittsburg.

The problem of the future of the American Association is still a live one. The membership has been greatly enlarged during the past year, due to great efforts of the officers rather than to any other cause. Previously it had scarcely increased for 20 years. A new attempt to put life into it is to be made at the next meeting, which will be held for the first time in the winter. It will be at Washington, D. C., in "Convocation Week," Dec. 29 to Jan. 3. As many of the colleges of the country have agreed to give their professors a vacation this week for the purpose of attending conventions, it is expected that there will be a large attendance.

The presidential address of Dr. Charles Sedgwick Minot, of the Harvard Medical School, on "The Problem of Consciousness in Some of Its Biological Aspects," created some sensation on account of some of its statements, which are rather too metaphysical for the ordinary mind to accept as really scientific. As he touched upon the subjects of matter and force, with which every engineer has to deal in his calculations, it may be well to spare a little space to show what one of the leading American biologists thinks about them. We quote a few extracts:

> Consciousness ought to be regarded as a biological phenomenon, which the biologist has to investigate in order to increase the number of verifiable data concerning it. In that way, rather than by speculative thought, is the problem of consciousness to be solved.

This is strictly scientific, as we understand science. All natural phenomena should be investigated by the method of procuring verifiable data rather than by speculative thought. The next sentence will not as readily find acceptance:

> The biologist must necessarily become more and more the supreme arbiter of all science and philosophy, for human knowledge is itself a biological function, which will become comprehensible just in the measure that biology progresses and brings knowledge of man both by himself and through comparison with all other living things.

What the biologist may think of matter, force and consciousness when he has become the "supreme arbiter of all science" is a matter for the future, but what he thinks now appears in the concluding portion of Prof. Minot's address:

> Now all the sensations of consciousness are derived from physical force, and all the acts of consciousness are manifested through physical force; hence if it has any real power, consciousness must be able to change the form of energy. . . . The hypothesis which I offer for your consideration is this: Consciousness has the power to change the form of energy, and is neither a form of energy nor a state of protoplasm.
>
> By this hypothesis there are two fundamentally different things in the universe, force and consciousness. You ask why I do not say three, and add matter? My answer is that we do not have and never have had any evidence whatever that matter exists. All our sensations are caused by force and by force only, so that the biologist can say that our senses bring no evidence of matter. . . . It would be a great contribution to science to kill off the hypothesis of matter as distinct from force. To conclude: The universe consists of force and consciousness.

We trust that the biologist will not be in any hurry to kill off the hypothesis of matter as distinct from force. The engineer needs the hypothesis of matter in his calculations as he needs the actual matter in his work, and he can more easily think of the fourth dimension of space than he can of the world he works in as without matter.

JOHN BUTLER JOHNSON.

The announcement of the sudden death by accident of Prof. J. B. Johnson, made in these columns two weeks ago, came as a shock, we are sure, to thousands of engineers in all parts of the country who knew him only by reputation, while in addition a deep sense of personal loss must come to every one who had the privilege of his acquaintance.

Few men were more widely known among American engineers than Prof. Johnson. His work, we need hardly say, was almost wholly as a teacher and a writer; but in both these fields he gained such distinction and success as has fallen to the lot of few.

John Butler Johnson was born in 1850 on a farm near Marlboro, Stark Co., O. The family, consisting of father and mother and seven children, moved to Kokomo, Ind., in 1866, and he attended Howard College at that place for a short time, after which he went to the Holbrook Normal School, at Lebanon, Ind. His first work was "teaching school," as has been the case with so many men in this country who have risen to prominent positions. After teaching at various country schools he became principal of the high school at New London, and later of that at Kokomo. In 1872, he went to Indianapolis as Secretary of the School Board, and remained there until 1874, when he entered the University of Michi-

J. B. Johnson.

gan, at Ann Arbor, and graduated in 1878. From 1878 to 1881 he was engaged on the survey of the Great Lakes, and from 1881 to 1883, he was an Assistant Engineer on the Mississippi River Commission.

After these six years in practical engineering work, he again took up the work of teaching, being appointed Professor of Civil Engineering in Washington University, St. Louis. Here he remained for sixteen years, and during that time, by his valuable contributions to technical literature and his activity in a hundred ways in connection with engineering work and engineering societies, he made his name and that of the institution with which he was connected well known throughout the engineering world.

In 1899, he was made Dean of the College of Engineering at the University of Wisconsin, and he entered upon his new field of duties with a zeal that brought quick results. There were about 250 students in the engineering schools at Madison when Prof. Johnson went there. At the present time there are over 500.

Prof. Johnson had formed most pleasant associations in Madison, since his removal to that place. A new residence was under construction for him and was to have been completed and ready for occupancy in the fall. His death occurred at his summer home at Pier Cove, near South Haven, Mich., where he had for years been accustomed to spend a large part of the summer vacation. He leaves a wife and five children.

While Prof. Johnson's professional reputation rests mainly on his contributions to technical literature, his work as a teacher of engineering held ever first place in his heart. He was deeply and sincerely interested in the work of technical education. His study of the German mono-technic schools, and his practical work in extending the benefits of technical training by the establishment of summer courses of study are recent illustrations of his constant activity in enlarging the scope and bettering the work of American technical education.

The two books by Prof. Johnson on which his fame will most largely rest are undoubtedly his "Theory and Practice of Surveying" and "Modern Framed Structures." Both these works met a real need in the profession, as their extensive sale proves. His "Materials of Construction" and "Engineering Contracts and Specifications" have also had a wide circulation. The two first-named books, however, reveal their author as a practical engineer, as well as a competent text-book writer; and while not a few teachers of engineering and writers of text-books upon it would find it hard to obtain a certificate of practical competency, certainly none would accuse Prof. Johnson of being a mere theorist on any subject he undertook to discuss.

Prof. Johnson was a prominent figure in many engineering societies. The mere catalogue of those in which he held membership is a long one. We note, however, the following: American Society of Civil Engineers, American Society of Mechanical Engineers, Institution of Civil Engineers (Great Britain), Western Society of Engineers, International Association for the Testing of Materials, Past President and Secretary of the Society for the Promotion of Engineering Education, a Fellow of the American Association for the Advancement of Science (and Vice-President of Section D), and a member of the committee for the proposed Carnegie Schools, at Pittsburg. He was also a member of the Engineers' Club of St. Louis, the St. Louis Railway Club, Missouri Historical Society, the Art Club of Madison, and President of the Science Club of the University of Wisconsin, and of the University Co-operative Association. He was an active member of the Unitarian Church and a life member of the Unitarian Conference.

Any mention of Prof. Johnson's life work would be incomplete which failed to mention his labors in connection with the "Journal of the Association of Engineering Societies," and upon the Index to Current Technical Literature, which was prepared and published under his direction for the seven years from 1884 to 1891. In closing his preface to that volume Prof. Johnson said:

> If the volume now put forth should contribute somewhat to the cause of good engineering in America, those to whom its usefulness is due will feel fully repaid for what has been largely a labor of love.

No better text could we choose from which to frame a tribute for the life work of such a man. It was his task as an engineer not to rear great bridges or perfect intricate machinery, but to make it possible for other men to achieve such things. All his work was indeed in the best sense a labor of love; and it was because of his love for it and the interest and enthusiasm which he brought to it that it was in so large a degree successful.

"The cause of good engineering in America." That was the cause in which John Butler Johnson's life was spent; and it is no small debt that the engineering profession owes to him.

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"The iron trade," said Mr. Carnegie a long time ago, "is either a prince or a pauper." These are the days when it reigns as a prince. The United States Steel Corporation reports net earnings for the first six months of 1902 amounting to $64,407,153. After paying interest and sinking fund charges on all its outstanding bonds, and providing about $6,800,000 for depreciation and reserve funds and special sinking funds, there was left $48,490,697—enough to pay a 3½% dividend on the preferred stock and 2% on the common, and leave $20,463,623 in the treasury.

In the face of such phenomenal prosperity the financial managers of this corporation are proposing to borrow $50,000,000, to add that sum to the company's bonded indebtedness and $2,500,000 to the company's annual interest charges, and—worse and more incomprehensible than all the rest—to pay $10,000,000 commission to the financiers who sell these bonds to the public, and effect the exchange of part of the company's preferred stock issue for bonds.

A merchant or manufacturer who should desire to borrow a thousand dollars on mortgage security, and who had to pay a commission of $200 to a broker to secure the loan, would be judged under most serious financial stress. The business man who should pay such a premium on borrowed money, at the same time that his business was paying phenomenal profits, would be universally considered an incompetent spendthrift.

How can it be that what would be the height of foolishness for the man in private business can become wise financiering in the case of a billion dollar trust?

Everybody knows that the United States Steel Corporation is hugely over-capitalized. Its securities bear no relation to the actual cost of its properties and plants, but are based on their earning power, something which has already been seen in the few months since the corporation was organized, to be subject to extreme fluctuations. A wise and conservative management would surely call a halt in the piling up of securities; and where improvements and additions to existing plants are needed, provide for them out of the huge profits of this period of unprecedented prosperity.

Tracklaying machines are not new in this country. On the contrary, they have been long known and to some extent used in American railway construction, so much so that when in our issue of April 24 we described a new device of this kind we considered it unnecessary to call attention to prior constructions in the same class or to recite in detail their history. This omission seems to have misled our German contemporary, the "Zeitschrift des Vereins Deutscher Ingenieure," and it concludes that we did not know that such machines are an old thing under the sun.

In its issue of May 24 appears an abstract of our article above referred to, together with the following editorial comment:

> . . . Certainly the general idea (of tracklaying machines.—Ed.) is not new, although possibly the present design may embody some new details; on the contrary, the origination of the idea and the construction of the first such machine must be credited to a German firm. As early as 1895 the Nurnberg Machine Co., in conjunction with Chief Engineer R. Behrends, built a tracklaying machine which gave excellent service in the construction of the railway from Eski-shehr to Konieh in Asia Minor.

The note further states that this machine averaged 1.5 km. (0.94 miles) of track laid per 8-hour day, with 41 men. If our contemporary wishes to claim the invention of tracklaying machines for its countrymen, it must go much farther back than the construction of the Asiatic railway. In Engineering News of Jan. 3, 1895, will be found a lengthy paper describing several types of tracklaying machines used in the United States. In connection with this paper there appears in the same issue an editorial entitled: "Tracklaying by Machinery," which our esteemed contemporary might study with profit. We quote below a few passages from this editorial:

> . . . perhaps few engineers, except those familiar with the construction of long lines of railway, understand the extent to which such machines are employed in order to effect economy in time and in cost of work. They are used mainly in the West, and on long lines. . . . In many cases the outfit is not sold, but is leased to the contractors by the owners of the patent, so that under such arrangements the machines are available for work on shorter lines than would be the case if the contractors had to purchase them outright. One make of machine has been used on nearly 60 roads in the West and South. . . . As to the speed of the work, the average is from 1½ to 2½ miles per day, varying according to the nature of the ground, the weight of rails and number of ties, and the general methods of working. . . .

From the above we may gather that the "general idea" of tracklaying machines is not a new one; and further that it was not a new idea in 1895, when the German machine which our contemporary refers to was built. On the contrary, tracklaying machines were actually in use in America as early as the year 1884, and very likely they may have been invented and used at a still earlier date.

A NEW PLAN FOR IMPROVING THE NEW YORK TERMINAL OF THE BROOKLYN BRIDGE

We know of no single engineering problem anywhere, on which so many experts have exercised their brains and on which so much ink has been shed—both printer's ink and drawing ink—as the improvement of the New York terminal of the Brooklyn Bridge. For more than fifteen years it has been a burning question, and for at least three years past its temperature has approached the melting point.

We have kept our readers informed of the various changing phases of the problem from time to time; and in the early stages of the discussion we used to record all of the various plans presented. That, however, long ago became impossible. Life is too short and other occupations too pressing to enable any save experts, who devote themselves to the work, to keep track of either the successive plans proposed for improving the Brooklyn Bridge terminal or the successive expedients adopted by the Carter contractors to escape the meshes of the law.

What may be called the official plans for remodeling the bridge terminal, however, we have chronicled as they appeared, with more or less fulness. During the past year there have been several such plans presented, of which the first and most notable was that proposed by a Board of Engineers consisting of Messrs. A. P. Boller, H. G. Prout and S. Whinery (Eng. News, Oct. 17, 1901).

This plan was particularly notable because it was the first formal recognition of the fact to which we have frequently called attention that the best way to improve the Bridge terminal is to abolish it, and continue the cars and passengers further on toward their destinations, so that the traffic will be distributed at a number of different stations, instead of being all concentrated at one as it is at present.

Briefly described, this Board plan consisted of an elevated railway line to connect the present bridge terminal with the terminal of the second East River Bridge a mile further north, which is now approaching completion. Over this elevated railway trains would run from bridge to bridge, distributing and receiving passengers at numerous stations along the line, where access would be easy to cross-town railway lines and to the east side elevated and surface cars running north and south, as well as the Rapid Transit lines.

Besides this connecting line, the Board proposed a second branch extending southward on Park Row and Vesey St., to distribute passengers bound for the office building district and land them nearer their destination. It also proposed an elaborate system of terminal loops for the Brooklyn surface cars, which run across the bridge on tracks laid in the carriageways.

A modification of the Board's plan was later prepared by Mr. C. C. Martin, M. Am. Soc. C. E., for many years Superintendent of the Brooklyn Bridge; and later still an entirely new plan for solving the problem was put forth by Mr. Gustav Lindenthal, M. Am. Soc. C. E., Bridge Commissioner of New York. Mr. Lindenthal, like the others, proposed an elevated railroad to connect the present Bridge terminal with the new bridge now approaching completion, but made its route coincide with the present Third Ave. line of the Manhattan Elevated R. R.. It may be added here that this plan as well as the two preceding provided for a branch line to connect this elevated belt line with the Manhattan Bridge across the East River, on which the foundation work has just begun.

"In a multitude of counsellors there is safety," runs the Scripture; but if the counsellors each recommended a different course, the one seeking advice may be in a worse dilemma than before. Each of the three plans above discussed has brought forth more criticism than praise; none of them has received sufficient public approval to justify the municipal administration in acting upon it.

In this situation Mayor Low turned over the knotty problem, with the solutions thus far presented, to the Rapid Transit Commission, which instructed its Chief Engineer, Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., to investigate the matter. Mr. Parsons' report was made public on July 1, and it is this latest official plan which we now wish to present to our readers.

At the outset of his report, Mr. Parsons describes the plans already presented, somewhat as we have done. He then continues as follows:

> The main objects sought to be obtained by these plans are:
>
> 1. To reduce the congestion at the Manhattan terminus of the bridge by providing other stations so as to do away with the necessity that now compels all the passengers for Brooklyn to take cars at the bridge itself.
> 2. To make a suitable through railroad in Manhattan between the termini of the Brooklyn, Manhattan and Williamsburg bridges, so that trains could be run from bridge to bridge without any delay by switching.
>
> The special advantage presented by Mr. Martin's plan is that the best route has been selected to gain the first result. A line along Center St. would undoubtedly gather more passengers and so serve the public better than a line along any other street. But Mr. Lindenthal's objection to the destruction of property by building such an elevated structure is unquestionably well taken.
>
> If a four-track elevated structure were built as proposed, the sides of the cars would be within 10 ft. of the windows of the Hall of Records, and at the station at

Worth St., allowing but 15 ft. for island platforms, the sides of the cars would be within 2 ft. of the building line of private property at that point. These distances mean practical destruction, so far as any beauty is concerned, of the buildings that the city has and is erecting at great cost; and the darkening of the street that would ensue from a four-track elevated structure spanning the street from building line to building line would forever destroy any other use of Center St. than as a railroad yard. I desire, therefore, to go on record with the Bridge Commissioner, that such a misuse of the street would be a desecration, a destruction of the city's property, and a depreciation of the abutting property, resulting in a lowering of the tax receipts to the city for all time to come.

Although the general proposition of the Martin plan apparently contemplates the building of but one elevated line, it must be distinctly understood that a principle of much broader import is involved. When the first line is constructed, branches and extensions will at once be projected; in fact, plans are already in existence looking to at least two elevated lines traversing the city from east to west, necessitating at least two crossings of Broadway. Property owners on streets other than Center and Grand Sts. are therefore interested in the action now to be taken, for whatever general plan of construction is adopted for the initial line will of necessity dominate the construction of all other connections. The general question before the Board and the public is, therefore, whether there shall be constructed a new system of elevated railways ramifying through the lower part of Manhattan?

Mr. Parsons then proceeds to describe his own plan, the character of which has doubtless already been guessed from the preceding discussion. It is in brief to substitute an underground road to connect the bridge terminals in place of the elevated road recommended by Mr. Martin. He shows that the bridge trains could descend to the tracks of such an underground road without the use of grades steeper than 4½%. The present maximum grade on the bridge approaches is 3.77%; and with electric traction in use, the increased gradient need involve no difficulty in operating, as is indeed proved by the experience of the Boston Elevated R. R., which has grades considerably steeper than this, where the ascent is made from the subway to the elevated structure.

Of course, one of the first questions that arises is as to the cost of construction of such an underground transit line. On this point we think it well to quote Mr. Parsons' report in full as follows:

In Mr. Martin's report an estimate is given by him as to the cost of constructing the elevated railway between the Brooklyn and Williamsburg bridges, the total figures being as follows:

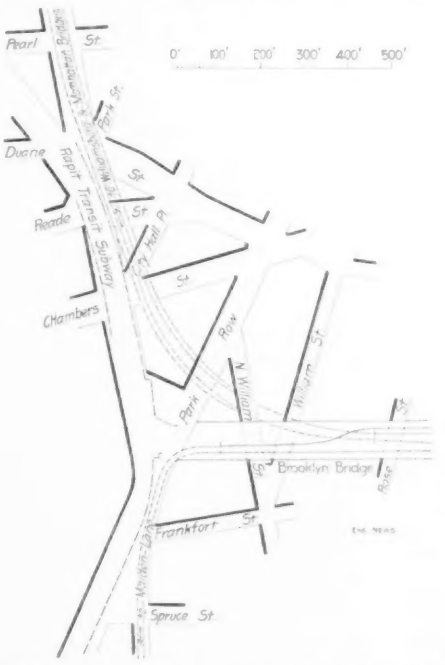
For construction, including station	$757,000
Property, damages, etc.	1,405,300
Total	$2,162,300

In the above estimate it will be seen what a large proportion of the cost is absorbed by abutting damages. The structural estimate made by Mr. Martin is, for the usual style of structure, correct; but the abuttal damage estimate is necessarily an indeterminate figure, depending upon an award by jury. Personally, I believe that a considerably larger amount than this would be granted. The actual value of the property along the proposed four-track section is at least $5,000,000, and the actual value of the property along the two-track section is at least $12,500,000, amounting together to $17,500,000, exclusive of any allowance for the city's own property. It will be noticed that Mr. Martin's estimate is only about 8% of the above amount. When it is remembered how close the cars would run to the abutting buildings, I am forced to the conclusion that the damages would be considerably in excess of the above estimate. Taking the same route and the same stations between the same points, I have computed the quantities that will be required for underground construction. Using the same unit prices that we are now paying on the Rapid Transit subway for similar work, and making a generous allowance for contingencies and extras, I place the cost of underground construction at $2,750,000. This figure is somewhat in excess of Mr. Martin's estimate, but I do not believe it will be in excess of what the actual cost of the proposed elevated structure and damage allowance together would amount to. The abutting property would, in the case of the subway, be benefited and not depreciated, and the city would receive an increased and not a decreased revenue from taxation.

Every impartial critic must appreciate the force of Mr. Parsons' argument. The insuperable obstacle which stands in the way of constructing additional lines of elevated railway in New York city is the matter of property damages. Except for this, additional lines of elevated railway would long ago have been built; in fact the Rapid Transit system itself would almost certainly have been constructed overhead instead of underground. Nearly all competent judges agree that with present real estate values on Manhattan Island, the additional cost of underground construction as compared with elevated structures is more than offset by the heavy property damages which the latter involve. Even if the contrary were the case, the fact that property damages are a most uncertain factor, dependent on the caprice and prejudice of courts and juries, and hence cannot be reliably estimated in advance like the cost of construction work, would be sufficient reason why a plan which eliminates the element of property damage should be preferred.

So much for the elevated trains which cross the bridge. It now remains to be considered what should be done with the surface trolley cars, which run across the bridge on tracks laid in the carriage-ways and are at present turned on four loop tracks at the Manhattan end.

As any of our readers who have given attention to the Bridge problem are aware, the crowding about these terminal loops in the rush hours is the worst feature of the present terminal. All three of the official plans referred to above—the Board's, Mr. Martin's and Mr. Lindenthal's—favored the retention of these loops at the present terminal, but proposed various schemes for reducing the crowding, eliminating the crossing of tracks at grade, etc. Mr. Lindenthal also suggested the use of a "moving sidewalk" to carry passengers across the bridge and permit them to take surface cars on the other side.



Map of Proposed Rearrangement of New York Terminal of the Brooklyn Bridge.

According to Plans Prepared by W. B. Parsons, M. Am. Soc. C. E., Chief Engineer New York Rapid Transit Commission.

In discussing this matter editorially in our issues of April 11, and Oct. 17, 1901, we urged that the same principles should be applied here, that are now admitted to be correct for the elevated trains and that some plan should be devised for continuing the surface cars on past the present terminal, so as to distribute passeners at a number of different points. We said in our issue of April 11, 1901:

Suppose now, that the present west bound surface car track on the Bridge roadway were continued on down Park Row and Nassau St., while a returning track would be laid in William St. (the next street parallel on the east). At a point near William and Spruce Sts., an incline would lead the cars back onto the eastbound Bridge roadway. Connecting loops would join these two lines of tracks, say through Spruce St., through Beekman St., through John St., and through Maiden Lane, or even farther down town, if that were deemed best. . . . . It would be an easy matter to build the line as a single-track subway.

We believe the feasibility of some such plan as this was investigated by the Board of Engineers which reported last October; but they thought it impossible to find room for the proposed subway at the bridge entrance.

Mr. Parsons, however, appears to think the difficulties not insurmountable, for he practically adopts our suggestion, as follows:

These trolley lines can be treated in a manner similar to what I have suggested for the elevated lines, namely, they too can be depressed, be brought under Park Row and carried in a subway south under Nassau St. to, say, Maiden Lane; and thence in a tunnel under Maiden Lane and the East River, to Brooklyn, rising to the surface at some desired point in the neighborhood of Borough Hall.

The difference between Mr. Parsons' plan and that suggested by us is his inclusion of another East River tunnel to be operated in connection with the present Brooklyn Bridge surface car tracks. Undoubtedly if such a tunnel is to be built it would be advantageous to operate it in the manner indicated. Even without such a tunnel, however, Mr. Parsons' recommendation is good evidence that the plan proposed by us over a year ago is practicable. It could be carried out, moreover, for a small part of the expense and in a fraction of the time necessary to construct an East River tunnel. If there is room in Nassau St. for the double-track subway proposed by Mr. Parsons, there is certainly room for the single-track subway proposed by us, and it could be built, moreover, with much less interference with the sidewalk vaults, and consequent opposition from property owners.

Compared with such a plan, any mere rearrangement of the loop tracks at the present terminal is a temporary and inadequate solution, for it continues the concentration of traffic at a single spot which is the root source of all the troubles with the present terminal. Even the proposed moving sidewalk across the bridge, proposed by Commissioner Lindenthal, we must regard as far inferior to the extension of the surface car tracks on the Manhattan side. It is better by far to bring the cars as near as possible to the passengers' final destination than it is to carry the passengers part way on some other conveyance and then compel a general change of cars.

One other feature in Mr. Parsons' report which is attracting much public attention is his suggestion as to the architectural treatment of the bridge terminal. We quote as follows:

When these improvements are finished, both cars and trains will have disappeared from the surface of the bridge from Rose St. to Park Row, and the present terminal station with the bridge across Park Row can be removed. This station building is unspeakably unsightly, and in every sense unworthy to constitute the approach to what is now the greatest bridge in the world. Aesthetic considerations would demand that when these buildings are removed the space be reserved to afford an uninterrupted view of the massive masonry towers and the graceful curve of the cables.

There is, however, a very general demand, both on the score of economy and convenience, for the construction of a great public building in which can be located the various department bureaus, for which building no suitable site seems available. With the disappearance of trains from the Manhattan entrance of the bridge and the abandoning of the bridge approach as a station, for which it was never intended, the area covered by the present station, together with such private property as can be readily acquired to the north, forms an exceptional site for such a public building. This building, by proper architectural treatment, could be made a fitting approach for the bridge itself by piercing the building with a large arched way to form a spacious entrance to the bridge, which arch would afford a fine vista of the bridge from City Hall Park. Such a building would afford accommodation for all the city offices beneath a single roof. It would be near the City Hall and the general Court House; it would face the City Hall Park, and moreover, would have light and air on the other three sides. If a similar amount of land had to be purchased near by, the cost of the land alone would probably be nearly equal to the cost of the whole construction above proposed; whereas, depressing the tracks as above suggested, this land becomes available practically without expense, as an incident to such construction.

The suggestion that a great municipal building should replace the ugly "trainshed" at the Manhattan terminal of the bridge is not, of course, new. It was included in the plans for a loop terminal made by the late A. M. Wellington fifteen years ago, and was prominently brought forward in the recent plan of Bridge Commissioner Gustav Lindenthal. But the improvements planned by Mr. Parsons, placing both elevated and sur-

face traffic underground, would make the construction of such a building far more feasible than it has ever been before. By proper architectural design such a building might be made a monumental portal to a great and world-famous bridge, without interfering at all with its use for municipal offices. A better and more convenient site for such offices could hardly be found, and there can be hardly a question that such a utilization of the land, and such a concentration of municipal departments under one roof, would be in the highest degree advantageous for the city.

LETTERS TO THE EDITOR.

Measuring Street Work on Steep Grades.

Sir: Referring to a communication in your issue of June 19, concerning the measurement of sewers laid on steep grades, it seems to me, that the natural way to measure work of this nature would be on the angle of the slope and not along the horizontal.

I have had cases which have come under my supervision in which the measurement along the horizontal has made a decided difference in the cost of the work, and as work of this kind is usually calculated by contractors by the lineal foot, it would not be fair to the contractor, in my estimation, to deprive him of this difference in distance.

The same question may be applied to brick or asphalt pavements laid on a grade, where the measurement taken along the grade line and the horizontal would make a material difference in the cost of the work. As this class of work has always been placed by the square yard, I have never hesitated to measure the work as actually laid, viz., along the grade line, giving the contractor proper compensation for the work done. Very truly yours,

John McNeal, Jr., Civil Engineer, Easton, Pa.

Mauch Chunk, Pa., June 30, 1902.

Query! What Was the Percentage of Voids in This Sand?

Sir: Referring to the matter of voids in sand, I note that on page 679 of Trautwine's "Engineers' Pocket Book" it is stated that loose sand from the shore contained 0.41 voids, the solid being 0.59 of the mass. By thorough shaking this was changed to 0.32 voids and 0.68 solid.

Recently I had occasion to test the voids in coarse sand, which had all passed through a ¾-in. sieve, 16 meshes to the inch. A box containing exactly 1 cu. ft. was used for measuring the sand, the box being jarred to settle it, and then filled full to the top. For measuring the water a cylindrical measure made of galvanized iron was used. This measure was 1 ft. long and 0.357 ft. in diameter, and contained thus exactly 1-10 cu. ft. of water. In addition I had a small rule, 1 ft. long and about 2-100 ft. square, graduated to hundredths. By this arrangement the water could be gaged to 1-1,000 of a cu. ft. After filling the box with water and working the sand, it settled 0.175 ft., representing a volume of sand of 0.825 cu. ft. It took 0.342 cu. ft. of water to fill the box. Now, the question is, what are the voids in the sand? Are they the full contents which would make 34.2%, or subtracting the settlement 0.175 from 0.342, which would give 0.167 as the voids in 0.825 cu. ft., equivalent to 20.2%. Which is which? You can readily see what bearing this would have in specifying concrete proportions, as does the State Engineer and Surveyor of New York, see page 64, paragraph 174, of Concrete Specifications, report for year 1900.

Respectfully, Civil Engineer.

New York, N. Y., June 15, 1902.

The Separation of Oil from Condensed Steam.

Sir: It was not the writer's intention in a letter which appeared in your issue of May 29 to belittle the work done by Mr. J. R. Bibbins, as set forth in his article published in your issue of May 22, wherein he outlines his process for the removal of oil from that very small proportion of total condensed steam from a power plant which may be designated as "oily drips." Exception was taken, merely, to his sweeping assertion "that the actual separation of entrained oil had never been obtained on a large scale," and in refutation thereof, mention was made of a number of machines which are actually accomplishing this work. In Mr. Bibbins' letter, in your issue of June 26, he relegates these machines to the following class:

> Several forms of water-purification apparatus, however, separate oil in small quantities, together with other chemical impurities, but do not attempt to purify condensation or oily drips from the engines.

If he will investigate the work of any of these plants he will find, that, as was distinctly stated, "all oily drips are mixed with, and purified at the same time as, the condensed engine steam."

While it is granted that the machine for the accomplishment of this treatment is somewhat less compact than an ordinary oil separator plus a machine to treat a much smaller amount of emulsion, yet it has this great advantage, that it *does separate the oil*, which is more than can be said of any mechanical separator that the writer has had the opportunity of testing.

Your correspondent took exception to the treatment with lime water of so soft a make-up water as that from Detroit River, thereby leaving in the water fed to the boilers a large amount of calcium hydrate. Mr. Bibbins says: "Mr. Booth also regards the introduction of lime water into the boilers as a 'questionable procedure,' obviously forgetting that it takes place in his own process to a similar extent." As no calcium hydrate is introduced into the boilers supplied by any of the machines instanced by the writer, he cannot qualify what he considers a just criticism.

In the writer's opinion "the main point to be kept in view . . . ." is not only "that the total condensation shall be made available for boiler feed," but also that the feed water shall be of the proper quality. It would, for instance, be better practice to discard say 10% of oily drips than to feed a like amount of lime water to the boilers.

Some of the discussion provoked by the original paper was doubtless due to misapprehension on the part of the writer of some of the author's statements. The writer believes that he now understands Mr. Bibbins' conclusions and finds himself in substantial agreement with them. He trusts that he likewise has succeeded in making clear his own views and that his statements, founded as they are on facts which can readily be verified, may meet with acceptance.

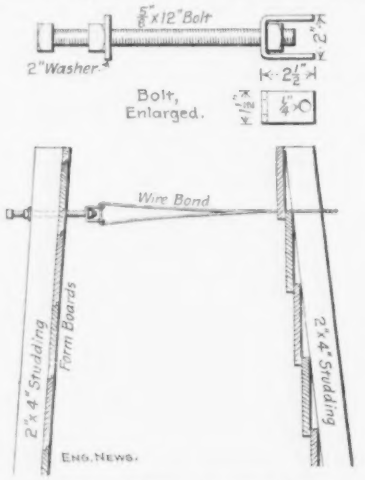
L. M. Booth.

126 Liberty St., New York, July 1, 1902.

Ties for Securing Concrete Forms.

Sir: The following device has been used very successfully on the Ulster & Delaware R. R., for bonding together the forms for concrete bridge abutments. Its principal advantage lies in its simplicity and adaptability to any point of the form where the concrete is varying in thickness.

It consists of a ⅝-in. × 12-in. bolt, threaded its entire length and passing through a hole in the studding holding the boards of the form, and having a nut and washer



A Tie for Holding Concrete Forms.

for tightening between the head of the bolt and the stud. The other end of the bolt then passes through a V or stirrup inside the form, and inside of which is the nut which holds the stirrup while the wire-bond passes through the hole in its extreme end. This stirrup remains in the concrete together with the wire, and as soon as the concrete sets the bolt is unscrewed, and the forms removed, showing but a small ⅝-in. hole in the face of the work to be plugged with cement.

So far as the writer knows, the device is not used on any other road, it being original, and is given for what it may be worth and with the hope that it may be found useful to others of the profession. Yours truly,

M. H. McGee, Assistant Engineer.

Rondout, N. Y., June 24, 1902.

The Origin of the Arch—Segmental and Hinged Arches—The Porto Rican Vara.

Sir: Since the publication of my paper on "The Design of Arch Bridges" in your issue of May 8, I have received letters from Mr. W. B. Parsons, M. Am. Soc. C. E., from which I venture to quote, since the matter to which they refer is of general interest:

> I note that you put down the design of an arch bridge with hollow spandrels as having probably originated in France in the eighteenth century. Permit me to state that this design is of Chinese origin and undoubtedly long antedates the eighteenth century. My own belief is that the arch itself, which is used as a bridge all over China, originated in that country, and not in Rome as is supposed, and that it was a re-invention in Europe. . . . . You are quite right that the Chinese precedents in this as in other things have but historical interest, because the Chinese design had no effect upon the world at large.

There was one error in my article, in your issue of May 8, which no one seems to have noticed and which I would like to correct. I wrote:

> The segmental arch is a chopped-off Roman arch, and is no arch at all—it is only a piece of an arch.

That statement is true as applied to the solid arch without hinges, which was the only one I had in mind when writing it; but it is not true of a hinged arch. The segment is the proper form for an arch with hinges at the skewbacks.

The extensive use which European engineers make of hinges in masonry arches seems to be due to the segmental form of their designs. In other words they adopt the segmental form and are then forced to use hinges to satisfy the conditions of stability. A more logical order to pursue in designing an arch would be to first decide whether the conditions would be best met by a solid arch or a hinged arch and then to design the ring accordingly. It is true that the result should be the same whether the segmental form or the hinges are first decided upon, *but* if the segmental form is selected first, the result will often be a hinged arch where a solid arch would suit the conditions better, as appears to be the case in Europe.

In reference to a communication in a recent issue of your paper giving the value of the Spanish vara, I enclose a copy of a report I made for the U. S. Military Government of Porto Rico in May, 1900. This gives the official Spanish vara, also the vara of common use in Porto Rico. It is probable that the vara of common use differs slightly in the various Spanish-American countries, but it is important to note that the vara of common use may be legal as evidenced by the fact that all the condemnation proceedings of the Porto Rican R. R. were based on it.

Very truly yours, Albert W. Buel.

32 Broadway, New York city, July 2, 1902.

(The sheet enclosed is reprinted below.—Ed.)

PUERTO RICAN MEASURES, MAY, 1900.

Royal Order of August 7th, 1883, published in the Official Gazette of Puerto Rico, Oct. 9, 1883, established the vara at 851.643 millimeters.

The cuerda is a square of 75 varas in each side, and is therefore equal to 43918.877551 sq. ft., or 1.0082386 acres.

The cordel is a linear measure, not in general use, and is 37.5 varas in length, or 104.78415 ft. linear. Thus, the cuerda is 2 cordels square, or 4 square cordels.

One caballeria equals 200 cuerdas.

The legal vara in English and United States feet is 2.794244 ft.

The legal vara is *not* the vara of common use in Porto Rico. Authorities differ as to the value of the latter—two being cited below.

Common vara of Porto Rico, 2.7424827 ft. to 2.74252 ft.
" cordel " " 102.8431 ft. to 102.8445 ft.
" cuerda " " 0.971231 acre to 0.9712573 acre.

The value of the meter used for these comparisons is from Lee's tables (Thos. J. Lee) "Professional Papers of the Corps of Engineers" No. 12, 1873.

1 meter = 3.280899 English ft. = 39.3708 English ins.
Log. of 3.280899 = 0.5159929.

Act of Congress of July 28, 1866, was in error in giving 1 meter equal to 39.37 ins.

Measuring Dredging Quantities "In Situ."

Sir: In your publication of April 7, under "Notes and Queries," you invite correspondence on a practical and accurate method of making estimates "in situ" of dredging. A reply to this is found in your edition of June 24, from two engineers who give their methods of computing the quantities in a certain case, but do not give their method in detail of the field work. The character of the work mentioned by these engineers warrants a thorough and careful survey before and after dredging. Having had considerable experience in hydrographic survey work, perhaps a practical and thorough method as outlined below will be of some benefit to parties interested.

It will be assumed that the basin referred to is situated as in sketch, with land contiguous or near one side or end.

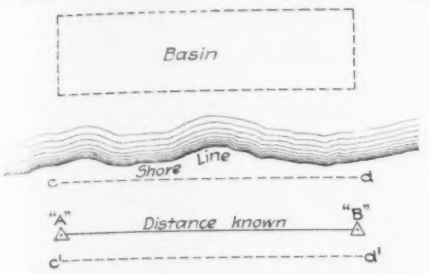
A and B are two observation stations so situated as to offer a clear field of vision over the area to be surveyed, and preferably visible one from the other, so that the observers can set zeros on each other; also so located that the intersecting angles on any point to be covered shall not be less than 30°. The distance between is accurately known either by direct measurement or by triangulation.

C—d, c'—d', are two parallel rows of stakes of such distance apart that a well defined range is established for a boat to run on across the area to be cross-sectioned. The spacing between stakes would vary with the accuracy required in the case. For irregular rock bottom, sections not more than 15 ft. apart should be taken, and preferably 10 ft.

I will assume that the basin lies in tidal water, in which case a gage reading to hundreds should be set at or near shore, opposite the center of the basin. This should be carefully connected with a bench mark on shore. If the depth of water is less than 15 ft., a pole can be used for soundings; if over 20 ft., a lead line is necessary which should be marked to half-feet, and should only be made and used by an experienced hand. The necessary field party consists of the engineer in charge, two transit men, a recorder to record the soundings, give the time for leadsmen to take soundings, and also to the signalman to raise the signal flag for location; a leadsman, tide-gage reader, two boatmen, signalman in boat and two flagmen ashore. While this party may seem large, after they are

broken in," a survey of the basin cited with cross-sections 10 ft. apart could be made inside of four days, the total cost of which would be approximately $125. This would involve the necessary accuracy of the work. Where rock dredging is carried on a variation of one-tenth of a foot in the depth referred to would mean $1,760 in the cost of the work.

The field operations would be as follows: The observers are stationed on "A," "B," their watches are set accurately with the watch of the recorder in the boat, the gages of the instruments are set in each other if possible; if not, on some common point which is connected with the base line A–B. Each observer should read his angles to the right, starting from zero. The two flagmen are stationed in the located range points in shore. The gage-reader is at his station with watch set with the others, and reads the gage every five minutes, recording time and gage reading. The boat has the engineer in charge, leadsman, recorder and signalman. Running slowly in the range line, soundings are taken regularly three or four to the minute, according to the depth of water. Some five or ten seconds before the even minute the recorder has the signalman raise the signal, and on the even minute, the signal is lowered. The observers ashore cut on this signal flag as it is lowered. Here we have a point definitely located, the soundings between the minute-points are interpolated, but the location will be very close, as the boat runs on a range, the soundings taken at a regular interval given by the recorder, and the boat run at as even a rate as possible. After the line is run out, another is taken in the same manner, the flagmen ashore moving up to the next two points on the base line. It is essential that the leadsman is intelligent enough to estimate tenths in a line graduated to half-feet; that he throws the lead and catches the sounding when the line is vertical and without sag. The lead line should be measured just before work, an hour or so after, and at the end of the work for the day. It should be kept under water when not in use. If there is a strong tidal current, work should be carried on only in slack or nearly slack water. Lines should be run against current.



The field work completed, the soundings are reduced to a datum plane, corrections for leadline and gage being made and the survey platted. While the soundings on the two maps—one of which is made before and one after the work—are not identically located, yet their frequency will permit of interpolating and averaging, so that the quantities removed can be computed by platting cross-sections and computing by end area, or by the borrowpit method. I have found the former more satisfactory, and within the accuracy required.

This method of taking numerous soundings and interpreting elevations for like points on the maps is far better than trying to locate soundings in the field, at identical points before and after work.

"M. S. C." and "J. S. C." in their articles state that the bottom surface of the basin they are estimating on was comparatively level before work started, so that soundings 50 ft. apart may be sufficient for the initial survey; but for the final one where the bottom is rock and necessarily irregular I would consider soundings 25 ft. apart rather scant.

Respectfully E. R. Conant.

U. S. Engineer Office, Savannah, Ga., June 23, 1902.

NOTES FROM THE ENGINEERING SCHOOLS.

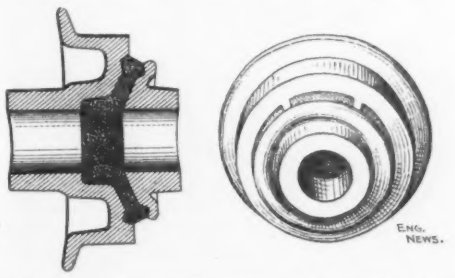
SHEFFIELD SCIENTIFIC SCHOOL OF YALE UNIVERSITY.—Prof. Russell H. Chittenden, Director of the School, announces a gift of "at least $500,000" received from Mr. Frederick W. Vanderbilt, a graduate of the Sheffield Scientific School in the class of 1876. Prof. Chittenden will not state the exact sum donated, but Mr. Vanderbilt authorizes the trustees to start a dormitory system for the scientific students, and promises to pay the bills. Mr. Cornelius Vanderbilt, a brother, spent $1,200,000 in building Vanderbilt Hall, ten years ago. Property has already been purchased for the new dormitories on College St.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.—The sanitary disposal of sewage, garbage and other town wastes, is made the subject of a donation of $5,000, sent to the Massachusetts Institute of Technology by a donor who does not wish his name to be known; but who promises to send a like sum for two years more. The work is to be conducted under Prof. Wm. T. Sedgwick, head of the department of biology.

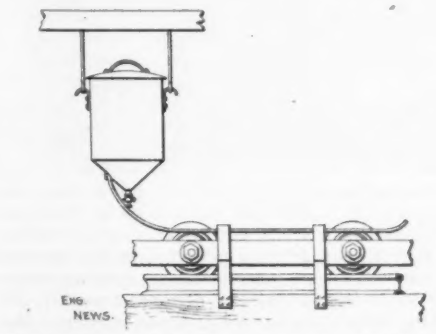
THE DESIGN OF CHIMNEY STACKS in Germany will be governed in future by an order recently issued by the Ministry of Public Works. Wind pressure on the structure and permissible stresses in the material are fixed by this order, as follows: The basal wind pressure, W, assumed in the calculations, shall be 125 kg. per sq. m. (25.6 lbs. per sq. ft.). The wind shall be assumed to act on the full vertical median section of the stack (making no deductions for sheltering by adjacent buildings), and the center of pressure shall be taken at the center of gravity of this section. If the area of this section be called F, then for different forms of stack the following effective pressures on the structure are to be used: For round stacks, 0.67 WF; for octagonal stacks, 0.71 WF; for rectangular stacks, 1.0 WF. With this wind pressure, no more than half the section shall be in tension. Tensile stresses shall be neglected in figuring the compression on the lee side, and the compressive stresses shall be calculated for W = 150 kg. per sq. m. (30.8 lbs. per sq. ft.). The permissible stresses on the brick work of the structure shall be: (1) for common brick masonry, laid in 1 to 3 lime mortar, 7 kg. per sq. cm. (100 lbs. per sq. in.); (2) for masonry of hard-burned brick laid in lime-cement mortar, 12 to 15 kg. per sq. cm. (171 to 214 lbs. per sq. in.). In any particular case a higher unit compressive stress, up to a maximum of 25 kg. per sq. cm. (356 lbs. per sq. in.), may be used, provided it be demonstrated to the satisfaction of the authorities, by actual test, that the contemplated unit stress will give a factor of safety of at least ten. If the foundation is made of concrete, the maximum stresses in the latter are limited to 6 to 8 kg. per sq. cm. (85 to 114 lbs. per sq. in.) when the concrete is simply deposited, or 10 to 15 kg. per sq. cm. (142 to 214 lbs. per sq. in.) when the concrete is rammed. The foundation pressure on good soil shall not exceed 3, or in exceptional cases 4 kg. per sq. cm. (43 and 57 lbs. per sq. in., resp., or 3.1 and 4.1 tons per sq. ft.). For the calculation of the stability, the actual unit weight of the material used must be found by test.

LUBRICATING THE WHEELS OF CHAIN CONVEYORS.

A neat plan for lubricating the wheels of chain conveyors has recently been brought out by the Link Belt Engineering Co., of Philadelphia, and is illustrated herewith. The rapid wear of wheels and rollers on chain conveyors, particularly where dusty or gritty material is handled, is well known to those who have used them. The difficulty of successfully lubricating the bearings of these rollers is also well known. To overcome these difficulties the Link Belt companies have devised and patented a wheel or roller having chambers for the reception of absorbent packing, as shown in the section and perspective view herewith.



Section and Perspective View of Roller for Chain Conveyor, with Lubricating Packing.



Method of Supplying Oil to Wheels of Chain Conveyor.

To keep this packing saturated with oil, at some convenient point on the line of the conveyor, an oil reservoir is placed and its outlet is adjusted to slowly deliver the oil to a long feed rod or wire placed close beside the conveyor, so that the packing on each wheel or roller rubs against this rod as it passes. In this manner continuous lubrication of each and every roller of the conveyor is assured.

PHYSICAL AND CHEMICAL LABORATORY OF THE J. I. CASE THRESHING MACHINE CO.; RACINE, WIS.

Until within quite recent years it has been the very general practice of manufacturing concerns to purchase their raw materials and supplies simply on the basis of quality claimed by the makers or parties selling the goods. Very frequently the goods were purchased on the reputation of certain trade names or special brands. With the development of more scientific methods of operation and management, however, and with the demand for greater economy in the cost of production, this practice had been found to be largely uneconomical and unsatisfactory. The important advantages resulting from the purchase of materials under well defined and carefully prepared specifications, and requiring the material to conform to certain conditions and tests therein specified, are now generally recognized, and many large consumers (including railway companies and manufacturing concerns), now prepare their own specifications, and even operate laboratories of their own for making the required physical tests and chemical analyses; as well as for certain experimental work undertaken with a view to cheapening the products.

Probably one of the largest of these laboratories for commercial purposes and one which carries on a great variety of work is that of the J. I. Case Threshing Machine Co., at Racine, Wis. This company makes every kind of machine used in threshing grain, also other forms of agricultural machinery, traction engines and various other styles of engines, so that its raw materials cover a very wide range. The laboratory was established about seven years ago, but has been developed and extended very considerably within the past few years under the direction of Mr. Frederick Robinson, Vice-President and General Manager, who has devoted much time and attention to this department. The head of the laboratory is Mr. W. G. Scott, who is not only an expert chemist, but has had many years of practical experience in the iron and steel, rubber, leather, oil, paint and other industries. Being, therefore, a thoroughly practical man, he is therefore able to judge of the commercial bearing or relation of the results of any particular chemical analysis or physical test. This, of course, is essential in a laboratory of this kind; for while any chemist may be able to make an analysis, yet in applying chemistry to practical work he will be entirely at a loss, and through lack of personal experience in the manufacturing or commercial side of the problem he may often do more harm than good Several other chemists and assistants are employed, and each man has a special line of work, which enables the laboratory to be run in a systematic manner.

The establishment and maintenance of this laboratory have involved heavy expenditures, but the results obtained have been found to show a material economy in the general operation of the plant. Work is done not only for this one company, but also for many other large concerns, this outside work including assays, chemical analyses and physical tests. Consequently, there is always a comparison of results obtained at different plants, which is of great value.

A very important feature of this department is in the making of specifications for raw material and devising systematic tests for the same. Orders have been issued to the chief chemist to construct a specification (with appropriate tests) for any kind of material used in the construction of machines made by the company. This undertaking is a very large one, and requires an immense amount of testing and research work. In this

work it is kept clearly in view that a specification, to be really valuable, should be rigid enough to exclude poor stock, but not so exacting as to compel the maker to charge an extra price in order to fill the requirements.

Two kinds of specifications are known to the trade—one for purchasing material, and the other as a "reference" specification. A "purchase" specification forms a contract, in which case the material must be exactly as specified. A "reference" specification is not a contract, but is used to define the difference between good and bad material, and such specifications are used as a guide, both in buying and for comparison when the goods are tested. The two different forms are valuable instructors, and even the workmen soon learn to classify the different grades of iron, steel, rubber, leather, paint, oil, etc.

The J. I. Case Threshing Machine Co. has a great many specifications finished at present, but some of them will be revised and many more new ones added, so that when the work is complete it will embrace the following:

Steel.—(Mild, medium and hard). Bessemer, open-hearth and crucible; comprising rivets, boiler plate, boiler tubes, firebox steel, spring steel, tool steel, structural steel, cast steel, etc.

Wrought Iron.—Extra or stay bolt, common merchant bar, and refined iron.

Cast Iron.—Gray-iron castings for cylinders, pulleys, gears, etc., malleable iron, and semi-steel.

Phosphor bronze, brass, Babbitt metal, tin, lead, zinc, copper, etc.

Rubber belting, packing, hose, etc. Leather belting and lace leather.

Cotton duck and cloth. Twine, rope, paper, etc.

Lubricating oils and greases. Paint oils, varnish, driers, etc.

Pigments for painting and heavy chemicals.

Coke, coal, sand, clay, firebrick, etc.

The specifications for cast iron, phosphor-bronze and other castings made in the company's foundry are as rigidly enforced as are the ones used in purchasing steel, etc. The foundry foreman, Mr. E. H. Walker, furnishes the different grades of cast iron and brass at a stated figure per ton, and all loss, whether due to poor material or bad molding, is sustained by him. The iron (three different grades) and the phosphor-bronze and brasses are mixed strictly by analysis.

For the foundry a mixing card is made out every day and a copy sent to the laboratory. This card shows the amount of coke, flux, pig-iron and scrap for each charge; furthermore, it is figured carefully and the percentages of silicon and sulphur are calculated and marked on the card as an "estimate." Occasionally the metalloids, phosphorus, manganese and total carbon are estimated.

The specification for foundry castings limits the silicon, sulphur, manganese, etc., according to the grade of iron produced; thus, for example, No. 3, or soft iron, must not contain more than 0.095% of sulphur, and the silicon, manganese, etc., must be between certain specified points. It is customary to allow a variation (either way) of 0.15 points on silicon, 0.010 for sulphur, 0.15 for manganese and 0.10 for phosphorus; therefore, the "actual analysis" and the "estimate" must correspond to the specified figures or be within the above variations.

One important part of the work of the laboratory, which requires more than the simple making of chemical analyses or physical tests, is in tracing the cause of failures and breakages, and (if necessary) finding a remedy for the trouble. Thus, if a shaft, gear, belt or other part of a machine prove defective or break from some unknown cause, the article is shipped to the laboratory and subjected to careful examination and test. If the material be poor or the workmanship not properly done, the chemist makes out a report to this effect and the defective part is replaced free of charge. If the piece submitted for inspection proves to be of good quality and the workmanship is properly done, the investigation is carried further, and the head chemist or the foreman of the department making the part in question is dispatched to the locality where the trouble occurs and ordered to make a thorough investigation in order to determine the source. If an unusual strain has been applied or unlooked for conditions introduced, the investigator is in position to suggest or make the change necessary to meet such foreign conditions. This is an expensive method, but fully repays the company, as it induces the confidence of its customers and tends to improve future work.

The laboratory occupies four rooms in the company's office building, one of these rooms being the office in which the reports are made up and the results of the various analyses and tests recorded for use and reference and for distribution to the various parties interested. The laboratory office is supplied with a library of several hundred volumes treating of varied subjects relating to chemistry, physics, electricity, heat, power, manufacturing, etc. Here are also some fine instruments, microscopes, barometers, hygrometers, anemometers, machines for electrolysis, grease testing machines, glue testers, etc. In the office there are also several fine scales—one sensitive to 1,200 part of a milligram, one of 1-20th milligram, one to a 1-50th of a grain, another to a quarter of a grain, and two balances for weighing from one gram up to a kilogram.

Two rooms north of the office are used as a physical laboratory. The principal machines used for physical tests are as follows: (1) A Riehle screw-power automatic testing machine (Fig. 1), for compression tests, transverse strain and tensile strength, with a capacity of 25 tons; (2) a smaller testing machine, with a capacity of 600 lbs., which is used for determining the tensile strength of wire, leather, twine, paper, cotton-duck and cloth; (3) a torsional machine, registering the power and degree of torsion; this is used for twisting pipe, phosphor-bronze test bars, and malleable iron; (4) a machine for testing the strength and percentage of stretch in rubber is known as a rubber tester, and is used in testing rubber belting, fire hose, etc.; (5) lubricating oils are tested in a practical manner on a Thurston oil tester; (6) Babbitt and other bearing metals are tested on a friction machine, which records the friction, rise of temperature or heating, pressure, wear, revolutions and distance traveled; all bearing metals are figured to a one-mile run; the bearing metal testing machine and vertical testing machine, with recording dial, appear opposite the doorway in Fig. 2; (7) a drop test with a weight of 10 kilograms (about 22 lbs.) is used for testing brittle metals, firebrick, paving materials, etc. The points considered in a drop or shock test are the height of the fall or total drop, the number of blows, and the inch or foot-pounds of energy in the blow.

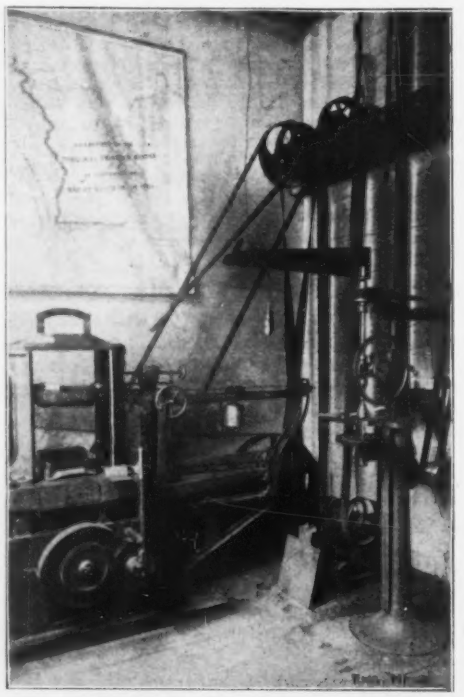


Fig. 1. Riehle Testing Machine and Bauer Drill for Testing Hardness of Metals.
Laboratory of J. I. Case Threshing Machine Co., Racine, Wis.

For determining the hardness of cast iron, brass, etc., the "Bauer" drill test is used (Eng. News, Vol. July-Dec., '98, p. 251). In this test the degree of hardness is determined by the number of revolutions made by a ⅜-in. drill (under a constant load) in boring a hole exactly ½-in. deep in the metal; the revolutions are counted by an automatic electrical device. The machine is shown in Fig. 1. The hardness of lead is 7 revolutions; that of tin 13 revolutions, and cast iron is graded as follows, and it may be noted that whenever the iron exceeds 300 revolutions there is a general complaint from all the machine shops:

	Revolutions for ⅜-in. hole ½-in. deep
Extra soft cast iron	100 to 150
Soft " "	150 to 200
Medium " "	200 to 250
Hard " "	250 to 300
Extra hard " "	300 to 350

The physical laboratory is well supplied with the latest improvements in measuring apparatus—micrometers of every description, wire gages, ring gages, cloth counters, machines for determining the twist of cordage, deflectometers, extensometers, drift gages, expanders, water, air, gas and electric measuring machines, etc.

The chemical laboratory, Fig. 3, is fitted up with shelves, cupboards, etc., and has the appearance of a well-regulated drug store, the bottles being of uniform size, properly labeled and arranged in systematic order. The chemical laboratory proper is fitted with two fume chambers, one for work on iron, the other for babbitt metal and alloys. As each chamber has a separate hot plate and burners, there is no danger of contaminating the different determinations by the different gases.

An elaborate assay outfit is included in this department, including crucible and muffle furnaces, grinding machines, etc. Assays are made on gold, silver, tin and copper ores. There is a full supply of suction pumps, compressed air apparatus, blast lamps, platinum ware, and burners of every description; also a gas apparatus, distilling apparatus, and a large supply of thermometers, hydrometers, measuring glasses and the special glassware and appliances for chemical work. Taken altogether, this laboratory contains apparatus, chemicals, etc., to the value of about $10,000.

Strictly speaking, the company's laboratory is a commercial affair and not a scientific feature of the manufacturing plant. The object of the laboratory is threefold—first, for analyzing and testing material; second, for research work, and, third, for scientific development and reference. Samples of all kinds of minerals, paints, oils, drugs, paper, cloth, leather, rubber, cordage, fuels, clays, brick, etc., are kept for reference, inspection and comparison. This collection of samples forms a valuable educator, not only for the chemist, but for the shop foreman.

The bookkeeping system employed is very systematic, and records dating back for years are a valuable feature. One set of books is used for research work, one for manufacturing formulas, one for recording chemical analyses, one for physical tests and one exclusively for foundry work.

In the chemical laboratory all determinations are made in duplicate; consequently every determination is a check analysis, and should be extremely accurate. The chemist is allowed the following variations in his work on iron: 0.05% on silicon, manganese and graphite; 0.02% on combined carbon; 0.005% on phosphorus and sulphur. In babbitt metal and alloys he is allowed 0.10% on tin and antimony and 0.05% on lead, copper, etc. That is, a check analysis on the same material must duplicate the first analysis within the above variations.

Two, and sometimes five, copies are made of the results of each analysis; one copy is made for the superintendent, and another is given to the foreman of the department where the material is to be used. If it be new material, purchased under specification, then the purchasing agent is also supplied with a copy. In cases of dispute, a copy is mailed to the firm which furnished the goods. In case of breakage, defective material, etc., the general agent, manager of agencies and

repair department each receive a copy of the analysis or result of the physical test.

The analyses and laboratory reports are all written in plain English, and, if necessary, explanations are given on certain subjects so that the foreman or other person receiving the report may readily comprehend every detail. No theories are advanced, or any complex scientific terms used in any case, as it is recognized that the business man has no time to study chemistry.

A satisfactory test on some kinds of material can only be obtained by means of a physical test, and in such a case no time is wasted on a chemical analysis. In other cases, an analysis is the only thing necessary, and no physical test is required to determine the quality. It is therefore essential to know the proper method to pursue in each case. In testing leather belting, for instance, no chemistry is needed, unless it is desired to know the tannage or the kind of filler used. The physical test gives the required results. According to the specifications, single belting must show a tensile strength of not less than 700 lbs. per in. of width. Rubber belting is tested for strength in a similar manner; it is also tested for "friction" and the weight of the cotton duck determined. The friction is determined by means of a machine which registers the number of pounds required to separate the plies. A chemical analysis of the rubber is also made in this case.

Coke and coal are subjected to a chemical analysis, also to visual inspection; sulphur is the detrimental feature in coke, and "slack" is the general fault found with coal. Coke is bought on specification, and if the analysis of the samples is not coincident with the specified analysis, the carload is rejected, no car being unloaded until after the analysis has been made.

Molding sand is bought on a "reference specification," in which case the specification is used as a guide, and is not expected to be adhered to closely. Sand is graded by number, according to its degree of fineness, the specifications giving a method for determining the fineness by means of a specified system of sifting.

Boiler tubes of open-hearth steel are subjected to a rigid physical test; a piece 3 ins. long, laid with its axis horizontal, must bend flat upon itself without showing fracture on the edges. Another piece, 1 in. long, set between the compressor heads of the testing machine with its axis vertical, must flatten upon itself in the shape of a ring without showing the least sign of fracture. On a well annealed 2-in. tube, No. 13 (B. W. G.), the pressure required to flatten such a ring varies from 22,000 to 32,000 lbs. The tubes are also given a drift test, expansion tests, etc. A chemical analysis is an important feature in this class of material, and is invariably made on every shipment received.

Babbitt metal and anti-friction alloys are tested on a friction machine; boxes are cast in a steel mold and then fitted to the journal, when any desired pressure or speed may be obtained by regulating the friction machine. The friction, rise in temperature, distance traveled, etc., are determined at the same time. The compressive strength, relative hardness, specific gravity and melting points are also determined.

Brass is tested physically for tensile strength, relative hardness, torsion stress and malleability. The determinations made on rope and cordage are as follows: Diameter, number of strands, number of twists per ft., weight per ft., tensile strength, stretch, and a chemical or microscopical examination of the fiber.

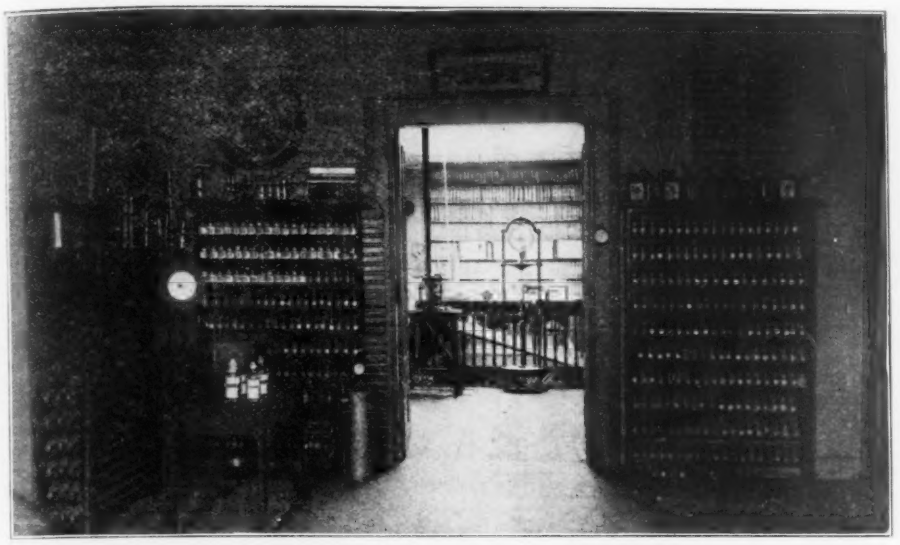


FIG. 2. INTERIOR VIEW OF PHYSICAL LABORATORY.

(On the table at left is the color-testing machine; paint samples are on the shelves; opposite the doorway are the small vertical testing machine with dial, and the bearing-metal testing machine.)

Paper (for writing, copying, printing, wrapping, etc.) requires a microscopical examination for the quality of fiber, a chemical analysis for moisture, cellulose, ash, etc. The thickness, weight, size, finish and strength are also determined. It may be noted here that the company has its own printing office for specifications, catalogues, etc.

Fire hose must meet specifications as to its manufacture; it must stand a specified pump pressure, must show only a certain amount of elongation under pressure, and fulfil other conditions essential to good material. The cotton cover must be of a certain weave, the inner tube of rubber must show a certain percentage of stretch, and the composition must conform to a given percentage of rubber, sulphur and ash.

Oils receive a physical test, in which the specific gravity, viscosity, flashing point, etc., are determined; also the acidity, burning and congealing points, etc. Oils are also generally subjected to chemical analysis.

On fuels and gas it is customary to determine the heat units in conjunction with an analysis.

Water for boilers is subjected to a technical or commercial analysis to determine its quality in regard to scale forming compounds. A "sanitary analysis" is made on waters used for drinking purposes.

Miscellaneous liquids, drugs, etc., are tested chemically for quality and strength.

Colors, tints and shades are determined by means of a chromatic disk machine which gives the relative percentage of pigment required to produce a specified tint or color, and the result thus obtained is recorded in a book, so that it is possible at any future time to reproduce the same color without experimenting. In this machine a large disk, painted the desired color, is fixed upon a horizontal spindle, to which are also fitted smaller concentric disks with adjustable colored segments. Thus, for a gray, the segments may be black, white and blue. The disk having these colors is revolved rapidly until it appears to be a single color, and the proportions of the three colors are adjusted until, when the disk is whirled, it appears to be the same color as the larger disk. The proportionate parts of the disk covered by the three colors then represent the proportions of these colors to be used in mixing a gray paint of the desired shade.

The glue testing machine (already mentioned) is worth some notice. A 15% solution of glue, after melting (at 140° F.), is allowed to cool and form a jelly, after which it is brought to a temperature of exactly 60° F. The glue, which is contained in a standard size glass beaker, is placed on the scale or balance of the glue testing machine; the weight in ounces is then noted. Over the scale pan holding the beaker is a stand with bevel gear and hand wheel, feeding a brass plunger slowly down as the hand wheel is turned. By running the plunger down the jelly is finally broken and the scale registers in ounces the weight required to break the jelly. The difference between the weight of the beaker of glue and the final index represents the strength of the jelly. The stronger the jelly, the more adhesive the glue. The main points in testing a glue are the strength of the jelly, the viscosity and the absorption.

FIG. 3. INTERIOR OF CHEMICAL LABORATORY.

(The two fume chambers are at the right.)

The most interesting part of the practical work of the laboratory is in the daily testing of the cast-iron bars from the foundry. Three test bars, 1 in. square and about 13.33 ins. long, are cast in a yoke exactly 13.33 ins. between the shoulders. The iron in cooling always shrinks more or less, depending upon the amount of silicon, sulphur, etc., in the iron; consequently by increasing or

decreasing the metalloids it is possible to regulate the shrinkage and chill to a nicety.

When the test bars are received at the laboratory they are placed in a similar yoke fitted with a micrometer and the shrinkage accurately measured. One-tenth of 13.33 ins. is 1.33 ins., which, being subtracted, leaves 12 ins. Therefore, deducting one-tenth the observed shrinkage on a 13.33-in. bar gives the shrinkage in 12 ins. The pattern maker usually allows ⅛-in. per ft. for shrinkage, but the kind of iron produced will change this figure entirely. This question has a very important relation to machine design and to foundry work. Thus, in making concaves for a threshing machine, it is absolutely necessary that the shrinkage be kept uniform, otherwise the cylinder teeth will not pass the concave teeth.

After the test bars have been measured for shrinkage, the dimensions (width and thickness, or diameter) are determined to 0.001-in. with a micrometer, after which they are tested on the screw-power testing machine for strength, deflections, etc. The transverse strength of the weakest iron must not be less than 2,000 lbs. and the tensile strength not less than 18,000 lbs. per sq. in. All bars are figured to the square inch, and are consequently comparable with other grades of iron, steel, brass, etc. The average tensile strength of hard cast iron is 25,000 to 35,000 lbs.; of soft cast iron, 15,000 to 25,000 lbs.; mild steel, about 55,000 lbs., and high carbon steel, from 120,000 to 175,000 lbs.; brass and bronzes range from 15,000 to 35,000 lbs. The tensile strength of wood varies from 6,000 to 15,000 lbs.

The other determinations made on the cast-iron bars are a test for hardness, by means of the Bauer drill (as already described), a determination of the depth of chill and a chemical analysis.

In mixing by analysis, the foundryman makes out a mixing card, in which he estimates the desired percentage of silicon, sulphur, etc. The chemical analysis of the iron shows the actual percentage of the metalloids, and it is wonderful how close to the actual result the estimate usually is. Under the old style of mixing (by grade) the iron was seldom uniform in quality and was likely to be very soft one day and too hard to machine the next day. When bad iron resulted, it usually required from three to five days to get back to normal conditions again. In mixing by analysis, however, the material may be kept very uniform, and if hard iron occurs by means of high sulphur the trouble may be corrected the very next day.

In conclusion, we may repeat the expression used by one of the firm: "A good laboratory and an expert chemist make a paying investment, saving money and preventing mistakes."

TESTS OF THE FRICTION OF SIDE BEARINGS AND CENTER PLATES FOR FREIGHT CARS.*

Your Committee on Side Bearings and Center Plates was continued from last year, with instructions to report on (1) a design of center plate, with a view to adopting dimensions for standards or recommended practice; (2) the location of side bearings; (3) uniform relation between center plate and side bearing; (4) the merits of anti-friction side bearings for relieving the center plate from part of the load; (5) will the use of anti-friction side bearings diminish the resistance between the wheels and rails?

CENTER PLATES.

As the second and third subjects mentioned above are dependent to a great extent upon the solution of the first problem, your committee has considered that until a suitable design of center plate has been constructed the matter of location of side bearings and their relation to the center plate should be held in abeyance. Your committee has therefore endeavored to obtain data which would enable it to present for your consideration a form of center plate for adoption as standard. Under the direction of Mr. T. W. Demarest, Superintendent of Motive Power, P. C. C. & St. L. Ry., a series of tests have been conducted of different forms of center plates and side bearings, and the results, as far as they have been completed, are given here. It has not been possible to make a number of the tests as originally outlined, due to non-receipt of material. In addition, there are a number of results obtained which do not appear reasonable, and in order to be satisfied in reference to them, it will be necessary to make additional tests. An attempt has been made to settle a number of points, but your committee does not regard the results as entirely conclusive.

*Abstract of a report of a special committee of the Master Car Builders' Association, presented at the annual convention at Saratoga, N. Y., June 18-20, 1902.

The object of the test with center plates was twofold—first, to ascertain the best metal for center plates; second, to define, if possible, the best shape. In making the test, two male center plates were bolted on the opposite sides of one end of a lever, each male center plate in turn engaging in a female center plate, the entire construction being forced together by a hydraulic press, from which were obtained total pressures ranging from 15.3 tons to 40.8 tons. The end of the lever in turn was moved through an arc by means of an air cylinder, an indicator and reducing motion being attached, in order to ascertain the amount of work done in turning the male plates in the female plates under the different pressures obtained. The result of these tests is shown graphically by Figs. 1 to 8, inclusive. The tests for side bearing friction were made in practically a similar manner, with the exception that the lever was pivoted at a point which would correspond to the average distance of side bearings from king bolt.

In order to ascertain, if possible, the best material for center plates, a number of plates were made as per Fig. 9 of three different materials—cast iron, malleable iron and cast steel. We were unable to obtain pressed steel plates of equivalent area or shape. The area, generally, of the plates was 100 sq. ins.

Test No. 1 of this series was made with the castings as they were received from the manufacturers, with no dressing or cleaning whatever. The cast steel, which gave the highest resistance, was extremely rough, had thick scale, fused patches on the surfaces, lumpy fillets, fins around the core holes, etc. The cast iron was not much better, and as a consequence the friction is close to the steel. The malleable plates were very smooth, clean castings, and gave a very much lower resistance. The results of this test shows the difference in friction or resistance due to the varying smoothness of the surface.

Test No. 2 of this series was made by grinding the surfaces with an emery wheel and chipping off fins and lumps in the fillets. This attention is assumed to be about as much dressing as it would be practicable to give the plates in actual practice. The scale was not removed, the casting simply being made smooth. In this test the resistance of the cast-iron and malleable-iron plates varies very little, if any, from the resistance obtained in the first test. The resistance of the cast-steel plates, however, has fallen most materially. The large drop in resistance of the steel plate was thought to be due to the crumbling of the thick, porous scale into a powder, which acted as a lubricant. This view was sustained by the fact that in the next test, with this same plate lubricated, there was but little further drop in the friction, the powdered scale in the latter instance preventing good lubrication.

In test No. 3 the same plates were taken as in previous tests and lubricated. The results of the lubrication are shown very conclusively in the very great drop in resistance.

In order to ascertain, if possible, if the low friction of the cast steel in test No. 2 was due to the powdered scale, the cast-steel plates were put in a lathe and the scale turned off and surfaces made smooth. They were again tested and the resistance was found to be lower than before the scale was removed from the surface. The effect of lubrication in test No. 2 practically eliminates the effect of the metal, as the plates of different materials, when lubricated, have practically the same resistance.

The object of the second series of tests was to determine the effect of the shape of the contact surface. Having found the effect of rough castings in the first series of tests, all plates were smoothed and fitted. All plates were made of the same metal, cast iron, and all except that designed by Mr. Klohs, for the Master Car Builders' committee, had 100 sq. ins. area of contact surfaces; the latter plate had 76 sq. ins. The results from test of flat plate in series No. 1 were taken for comparison with the curved and spherical plates in series No. 2

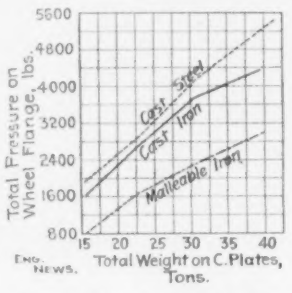


Fig. 1. Diagrams Showing Results of Tests of Center Plates for Best Metal. (Rough castings, not lubricated.)

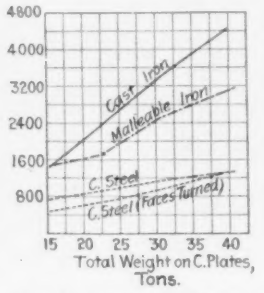


Fig. 2. Diagrams Showing Results of Tests of Center Plates for Best Metal. (Smoothed castings, not lubricated.)

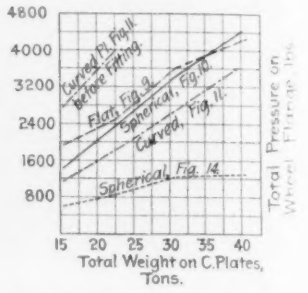

Curved, Fig. 11, Before Fitting
Flat, Fig. 9
Spherical, Fig. 10
Curved, Fig. 11
Spherical, Fig. 14
Total Pressure on Wheel Flange, lbs.
Total Weight on C. Plates, Tons.

Fig. 4. Diagrams Showing Results of Tests of Center Plates for Best Shape. (Castings smoothed and fitted, not lubricated.)

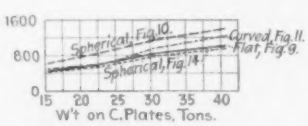


Fig. 5. Diagrams Showing Results of Tests of Center Plates for Best Shape. (Castings smoothed, fitted and lubricated.)

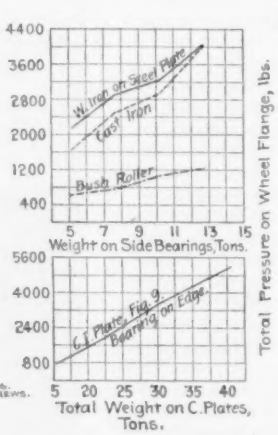

W. Iron on Steel Plate
Cast Iron
Bush Roller
Weight on Side Bearings, Tons.
C. I. Plate, Fig. 9, Bearing on Edge
Total Pressure on Wheel Flange, lbs.
Total Weight on C. Plates, Tons.
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Fig. 7. Diagrams Showing Results of Tests of Combinations of Center Plates and Side Bearings. (Smoothed castings, not lubricated.)

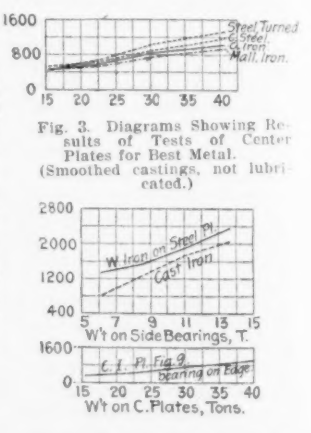


Fig. 3. Diagrams Showing Results of Tests of Center Plates for Best Metal. (Smoothed castings, not lubricated.)

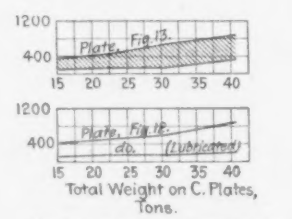


Fig. 6. Diagrams Showing Results of Tests of Flat and Ball-Bearing Center Plates, Figs. 12 and 13, respectively.

Fig 8. Diagrams Showing Results of Tests of Combinations of Center Plates and Side Bearings. (Castings smoothed and lubricated.)

FIGS. 1 TO 8. DIAGRAMS SHOWING RESULTS OF TESTS OF SIDE BEARINGS AND CENTER PLATES BY COMMITTEE OF THE MASTER CAR BUILDERS' ASSOCIATION.

Test No. 3 of this series was made by grinding the surfaces with an emery wheel and chipping off fins and lumps in the fillets. This attention is assumed to be about as much dressing as it would be practicable to give the plates in actual practice. The scale was not removed, the casting simply being made smooth. In this test the resistance of the cast-iron and malleable-iron plates varies very little, if any, from the resistance obtained in the first test. The resistance of the cast-steel plates, however, has fallen most materially. The large drop in resistance of the steel plate was thought to be due to the crumbling of the thick, porous scale into a powder, which acted as a lubricant. This view was sustained by the fact that in the next test, with this same plate lubricated, and it was expected that the flat plate would have the lowest friction on account of the tendency of the inclined surfaces of the other plates to wedge together. The results obtained from the tests do not at all confirm this theory. They do not show the superiority of the flat plate, and they do show an abnormally low friction for the plate Fig. 14, designed by Mr. Klohs. The curves Figs. 4 and 5 show very plainly, as in the first series of tests, the good effect of lubrication, and indicate that when well lubricated the shape of the plate does not materially affect the resistance. The tests with the lubricant do show, however, that the resistance of the flat plate is lower than the spherical plate, Fig. 10, and curved plate, Fig. 11, and about the same as the Klohs plate. We can see nothing in the contour of the Klohs plate which would tend to produce lower resistance than we have obtained from the spherical plate, Fig. 10. The unsuspected results are due, we believe, to the condition of the surfaces of the plates. The flat plate required but little grinding and fitting to give it a good bearing. The spherical and curved plates, however, fit badly in the rough, and required hard grinding, filing, etc., to bring them to a reasonable fit. The final condition of the surfaces was, therefore, very much better with the spherical

and curved plates than with the flat plate. The Klohs plate was ground especially hard on the steeper slopes, and brought down to a good fit in the bottom, which is nearly flat. It is very probable that this plate was ground too hard on the outer ring, concentrating the weight on the inner ring, which is nearly flat and of much smaller diameter, with the resultant low resistance. Further tests in this series will be made by placing the plates in a lathe and fitting them carefully over their entire surfaces, removing all scale and testing them dry and lubricated, in order to settle definitely the conflicting results.

Further tests in this series were made with special plates, namely, a small experimental plate, Fig. 12, with flat surfaces, designed to be used without a center pin, and having a face only 4 ins. in diameter, with the idea that it might be possible to use such a plate in conjunction with a roller or other anti-friction side bearing to assist in maintaining the balance of the car. It was desired to have this plate chilled, as only a very hard surface could stand the heavy pressures. The plates were received soft from the foundry, however. The friction of this plate is very low, but it cut badly both when dry and when lubricated, the cutting in both instances taking place in the center of the plate. The second special plate tested in series 3, as shown by Fig. 6, was the ball-bearing center plate, Fig. 13, used by the P. & L. E. R. R. This plate gave the lowest resistance recorded under the conditions. The balls lie in pockets, which, in length, are about twice the diameter of the ball and enough larger in width than the diameter to allow the ball to roll freely. The bottom of these pockets curves upwards at the ends, so that the ball begins to roll up hill as soon as it leaves the central position, and as the slope of the pocket is curved, the resistance of the plate to revolution increases as the ball rolls up the slope. The cards taken in this test show a gradually ascending line to a point where the ball seems to lock and stop rolling; the top plate then slides on the balls. The starting and final resistance is shown on curves for each pressure.

The remaining series of tests were for the purpose of ascertaining, if possible, the combined effect of the center plates and side bearings, as when a car rolls or tips in passing around a curve, and bears on both the center plate and the side bearing. The flat plates, Fig 9, were held apart on their lower edges by spreaders, and inclined at an angle equivalent to closing a ¾-in. clearance, with side bearings 28 ins. from the center. The pressure on the back of the plates being uniform, half the weight was taken by the spreaders and half the weight by the edges of the plates. The resistance shown for the plates was therefore doubled to make it comparable with the standard weights used with other tests. The results thus derived are about the same as with the plate bearing on full surface in first series.

The side bearings were tested under comparatively low pressures of from 5 to 12 tons total. It was found impossible to exceed these pressures, owing to the fact that the apparatus would lift from the floor. The results of this series show also the effect of good lubrication, and also show that it is from the side bearings that most of the flange resistance is derived. The roller side bearing gives the best results, as was obtained from the roller center plate. All tests, both of center plates and side bearings, show the desirability of thorough lubrication, the castings to be smooth, but scale allowed to remain on. A thick grease, furnished by the Galena Oil Co. for the purpose, was used for lubrication. It is impossible to say how long the grease would last in service. The ball plates and roller side bearings gave very good results, although the ball center plate was badly cut in the upper groove by locking of balls in the pockets. Further, with the larger plates, that is, all plates with the exception of small flat plate, Fig. 12, no cases of cutting, even under the pressures used, were experienced when there was a good bearing over the entire surface.

It will be noted in the statements that the resistance of the plate to turning is reduced to the wheel flange. We regret that our tests have not been comprehensive enough to permit us to make definite recommendations as to minimum contact area of plates under definite loads, the shape of the plate, or the material from which it should be made. The machine used was rather crude, and it is being redesigned with the idea of carrying these tests to a conclusion.

ANTI-FRICTION SIDE BEARINGS.

The fourth and fifth subjects assigned to your committee relate to anti-friction side bearings, and are as follows: The merits of anti-friction side bearings for relieving the center plate from part of the load. Will the use of anti-friction side bearings diminish the resistance between the wheels and rails? For the committee to determine these qualifications, it would be necessary to conduct a series of tests extending over a period of years. This was thought unnecessary at the present time. A circular was therefore addressed to each member, asking his co-operation to the extent of furnishing to the committee the result of such tests as had been made, and which was available. Of the members replying, those giving opinions or furnishing data control about one-fifth of the car equipment represented in the association. The replies received (with the exception of two or three, referred to hereafter) gave no details of tests, but were general in character, indicating the opinion of the writer based on observations of bearings in service, rather than from any special tests. As there seems to be a vast difference of opinion as to the merits and usefulness of this device, and as the reasons for same and suggestions for improvement in construction are given, a brief quotation from some of the replies may be interesting.

1. Our opinion is that there is some merit in the anti-friction side bearings in relieving the center plate from part of the load. With them we decrease the distance between side bearings to the minimum, but where clearance is maintained between side bearings (as is our aim), of course the side bearings would not relieve the load on the center plate except on curves or at high speed, where the momentum or wind resistance might cause a rolling motion to the car, and think their use diminishes the resistance between wheels and rails only in going from a curve to a tangent, or vice versa. We have a number of heavy passenger cars, including dining cars, which are equipped with anti-friction bearings, and which have been in service from one to three years, and while we have not made any definite tests, we are of the opinion that they have a tendency to prevent flange wear, as mentioned above. We find that the rollers stand the wear very well, but the frame which contains them, and the small journals supporting the rollers, frequently get out of order, as the bending of the journals causes bunching of the rollers, thereby preventing their natural movement. The journals also have a tendency to cut into the frame horizontally, which renders them inoperative. This defect might be improved considerably by making them on a larger scale throughout, maintaining about the same number of rollers, only larger, which would, of course, alter the design of the car somewhat in order to get the necessary clearance between the top and bottom bolsters.

2. We have only a few anti-friction side bearings in service, and these are under passenger cars. With the exception of one or two broken ones, we have had no trouble with them, but we have no information as to their advantage over plain side bearings. A considerable number of our freight equipment has single-roller side bearings. These have given a great deal of trouble from flattening and sinking into the top side bearings. We are removing them as rapidly as possible. My experience with modern stiff truck and body bolsters indicates that anti-friction side bearings are not necessary, but that an anti-friction center plate is much more desirable.

3. We have no definite data to show that there is any special advantage in the use of anti-friction side bearings. With those we have in passenger car service, the flange wear seems to be as great under cars equipped with this class of bearing as with the other. As to the use of anti-friction side bearings on freight cars, some of which we have had occasion to examine, we find that they get out of order and are not a good bearing for freight service.

4. I have not yet had any experience with anti-friction side bearings and center plates which do not show a decided tendency for the rollers to wear holes.

5. As to the merits of an anti-friction side bearing, if you could get a satisfactory one, no doubt it would be of service in aiding the curving of a car. I know positively where wrought-iron bearings or steel bearings come together it is very hard in the curving of a car; in fact, I have seen cars come off a curve and run on a straight line for one-eighth of a mile before the flange of the wheel would leave the side of the rail. On this line we generally use cast-iron side bearings, the bearing on the truck having a pocket, and in this pocket we use greased waste, and think this is quite an advantage to the cars in curving. I believe where the side bearing is not performing satisfactory service at low speed, that at high speed it will give better results. All accidents that we have had on account of side bearings have occurred at low speed.

6. We do not use anti-friction side bearings. Our policy has been to construct our bolsters with sufficient strength so that the weight of car could be carried on the center plates, and would provide a liberal clearance between the side bearings, but I am not sure that even with this arrangement that the truck would readily adapt itself to the curves, as the weight of the car would naturally be carried by the side bearings on the inside of the curve, due to the elevation in the track, and that a frictionless bearing would materially aid in allowing car to adapt itself to the curvature, and would relieve the strains on the flanges. Our standard bottom side bearing has a cavity that is filled with waste and is kept lubricated, which, in a measure, relieves friction and resistance, but at the same time it is my opinion that a cheap, durable, frictionless side bearing is desirable.

7. The use of anti-friction side bearings for relieving center plates from part of the load is not justifiable on new equipment, where a body bolster and truck bolster can be used of sufficient strength to carry the load on center plate. On old cars it may be found economical to use an anti-friction side bearing, where the body bolsters and truck bolsters are not strong enough to carry the load. On passenger equipment the case is entirely different, and the use of anti-friction side bearings is justified by the desire to have an easy riding car; that is, were the weight carried on a free center plate there would be considerable rolling of the car body, which would be disagreeable in this kind of service.

8. We have 100 cars equipped with roller side bearings and 100 cars equipped with rigid cast-iron bearings, and we have removed more sharp flanged wheels from the cars equipped with roller bearings than from the cars with cast-iron bearings. This does not show favorably for the anti-friction side bearings, though we know theoretically the principle is correct. Whether in practice they will reduce the friction between the wheels and rails is yet to be determined. We have just received 1,600 new cars equipped with anti-friction bearings, and three or four years hence we can determine as to their merits.

9. We do not allow our cars to rest on their side bearings at all; it all comes on the center plates. We have roller bearings, but there is not any wear on them whatever, as but very few of them ever touch. This is accounted for by the body bolster we use. In answer to your second question, will say that anti-friction side bearings will certainly diminish the friction on the wheels and rails, providing the bolsters are not stiff enough to carry the load, but if they are stiff enough, I see no reason for using the anti-friction rollers, and I think where you depend on them you are going to have cut flanges, a thing which we do not know of here.

10. We have placed the anti-friction side bearings under numbers of our passenger cars, and have already noticed, particularly in our limited trains, that the flange wear on steel wheels has measurably decreased on account of their use. These roller side bearings have been in use nearly two years, and as yet appear to be in good condition.

11. We have several different devices in service under our cars. From my observation, some have given excellent results, while others have not. However, the anti-friction bearings overcome the heavy resisting strains produced by rail and flange wear when rounding curves. These bearings should relieve the center plate to some extent of the heavy weight, part of which should be borne on the sides. From my experience, I find that anti-friction side bearings diminish the flange wear and prolong the life of the wheels. These bearings must have rollers of hardened steel or chilled faces, and face plates of like material to avoid cutting.

12. We have made some trials of the frictionless side bearings under 100,000 lbs. capacity self-clearing, steel gondola cars. The side bearings were not successful in the first instance, for the reason that they were of insufficient strength in themselves, and were provided with reinforcing plates under them of insufficient strength to stand the shocks under these heavy cars when rounding curves; the side bearings became deflected, and consequently the rollers were unevenly worn. We have made some trials of center plates and side bearings where chilled or hardened balls were used. The grooves in which these balls revolved were similarly chilled or hardened. The balls wore flat to a greater or less extent, and in addition the grooves in which the balls revolved became very flat and uneven, and eventually caused breakage of some of the center plates. Quite a number of cars in our express trains have been provided with frictionless side bearings, and we understand that the Pullman people claim that the flange wear of the wheels is reduced considerably, and we feel that the trucks under these cars do curve somewhat more readily than with ordinary side bearings. However, when the

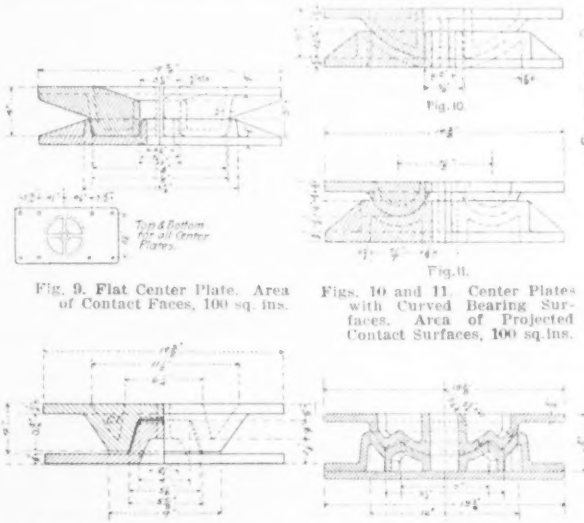


Fig. 9. Flat Center Plate. Area of Contact Faces, 100 sq. ins.

Fig. 10.

Fig. 11.

Figs. 10 and 11. Center Plates with Curved Bearing Surfaces. Area of Projected Contact Surfaces, 100 sq. ins.

Fig. 13. Standard Ball-Bearing Center Plate; Pittsburg & Lake Erie R. R.

Fig. 12. Center Plate for Use Without Center Pin Having Chilled Contact Surfaces, 4 ins. Diameter.

Fig. 14. Center Plate Designed by Mr. Klohs for M. C. B. Committee. Area of Contact Surfaces, 76.7 sq. ins.

Fig. 15. Pressed Steel Center Plate. Area of Contact Surfaces, 46 sq. ins.

FIGS. 9 TO 15. DETAILS OF CENTER PLATES TESTED BY COMMITTEE OF MASTER CAR BUILDERS' ASSOCIATION.

frictionless side bearings have too much pressure on them, reducing the center bearing, the cars rise badly. This is remedied by giving more center bearing.

13. The result of test some two years ago demonstrated the fact that anti-friction side bearings, adjusted to relieve the center plates of part of the load, were not superior to the conditions with load carried on center plates alone. The only service test of cars having roller side bearings in contact were 30-ton box cars built at our shops, from which no data could be obtained, as in nearly all cases when cars were returned here the bearings were broken; from this, however, I would be led to believe that with cars solid on all four side bearings, even though they may be of roller type, does not afford sufficient flexibility, and which I think would either result in broken bearings or would not produce results desired. It would seem that cars when down on their side bearings, plain bearings being used, is becoming more objectionable, and we have lately received instructions from several of our connecting lines that freight equipment must be inspected and adjusted to give side bearings clearance; otherwise cars offered in interchange will be rejected. From such data as we have obtained, it is evident that the use of anti-friction side bearings will diminish resistance between the wheel flange and the rails, thus prolonging the life of the wheels. In my opinion, cars should be equipped with a metal bolster of sufficient strength to carry the required load of the car without a perceptible deflection, as I am of the opinion that where the weight would be distributed equally between the center plate and the side bearings, especially in running over straight roads, that the hammer blow created by running over rough track, railway crossings, frogs and switches would cause the rollers to become flattened, which would, in a measure, destroy their usefulness.

The following results of tests of side bearings were submitted by members in answer to the circular of the committee, and are given below as bearing on the general subject:

PITTSBURG & LAKE ERIE R. R. CO.—This company has recently made some tests of ball-bearing center plates and side bearings, which may be of interest to your committee. On June 1, 1897, one 60,000-lb. capacity gondola car was equipped. The construction consisted of four steel balls 2¼ ins. in diameter, between two malleable-iron center plates, the lower plate having four grooves equally spaced, 4 ins. long, ¼-in. deep at the center, running out to nothing at the end. Lengthwise the grooves conformed to the radius of the bearing surface of the center plate. The upper plate had a groove ¼-in. deep, corresponding to the diameter of the balls and extending all the way around. The side bearings had each one steel ball of same diameter as those used in center plates; each bearing had a groove 15 ins. long, same diameter as the ball, straight on the bottom, but curved to proper radius. Balls were protected by deep flanges on each bearing, the top passing down over the outside of the lower. The ends of the flange on upper bearing were cut so as to permit of the greatest curvature of truck. After the car had been in service three years, proving clearly that the device was entirely practicable, a careful test was made to establish its value in the way of reducing flange and rail wear on sharp curves. A turntable 7 ft. long was made so as to determine, by the use of a dynamometer, the actual power required to displace a truck 2 ins. at the end, or 4 ins. in its length, equaling a 154° curve. The appended report is the result of the trial:

Curve resistance on cars equipped with the Hartman ball-bearing center plate and side bearing, in comparison with the ordinary flat surface center plate and side bearing.

First Test.

Flat center plate and side bearing, with ⅛-in. deflection of body bolster resting on side bearing:

	Resistance.	
Required to start truck	800 lbs.	100%
Required to displace truck 2 ins.	1,100 lbs.	100%

Second Test.

Flat center plate, without side bearing:

	Resistance.	
Required to start truck	275 lbs.	34%
Required to displace truck 2 ins.	525 lbs.	48%

Third Test.

Hartman ball-bearing center plate and side bearing, with ⅛-in. deflection of body bolster resting on side bearing:

	Resistance.	
Required to start truck	75 lbs.	9%
Required to displace truck 2 ins.	450 lbs.	40%

Fourth Test.

Hartman ball-bearing center plate, without side bearing:

	Resistance.	
Required to start truck	75 lbs.	9%
Required to displace truck 2 ins.	325 lbs.	29%

This report, to our mind, clearly indicates two things, namely: We should have a frictionless side bearing to assist cars around curves with high outside elevation, but on straight and level track the load should be carried on the center plate, and by all means on a ball bearing. The most valuable feature in the center plate in question is the dish in the grooves in the bottom plate, which answers two purposes, one being to keep the balls properly spaced and the other the tendency to straighten the truck quickly after leaving a curve, this being explained by the fact that the sluing of the truck on a curve forces the balls up the inclined plane of the grooves, and as soon as straight track is reached they naturally gravitate back to their proper position.

For your information, we append a report of the service of the car in question:

Car built	April, 1896
Equipped with Hartman appliance	June, 1897
Miles run from June, 1897, to date	11,323
Approximated loaded mileage	7,548
Capacity of car	60,000
Tons carried one mile	266,440

Wheels show no flange wear up to date. The perfect condition of the wheel flanges demonstrates its value, not only as increasing the life of the wheel, but reducing train resistance. L. H. Turner, Superintendent M. P.

DULUTH IRON RANGE R. R. CO.—Not considering the 200 cars built by the Illinois Car & Equipment Co. in 1899, there were 512 ore, flat, box and logging cars equipped with automatic frictionless side bearings in 1899 and 1900. Exact date of applications of the side bearings to 278 ore cars, 38 box cars and 70 flat cars (386 cars in all) in 1899 and 1900 are known, and also the dates of six applications to ore cars in 1901.

TABLE I.—Service of Automatic Frictionless Side Bearings. Effect Upon Flange Wear.

Year.	Wheels removed, all defects.	Removed for sharp flanges.	Percentage.
1899	908	254	25.5
1900	2,248†	463§	20.6
1901	1,815‡	322	17.7
1902*	372	24§	
	6 Approximate for year.	6	
	2,232	144 approximate.	06.0§

The wheel records, Table I., show that for the year of 1900, after the automatic frictionless side bearings had been just applied, but had not been in service long enough to have appreciable effect upon the wheel flange wear, 463 wheels were removed from box, ore, flat and logging cars for sharp flanges. During 1901, when the bearings were in service on 512 old cars of these classes, and materially affecting the flange wear, only 322 wheels were removed for worn flanges, a reduction of 30%, notwithstanding that the wheels were an average of four years old when bearings were applied, that the car mileage had been increased, that train hauls had become greater, and that the equipment was one year older. The indications are that the flange wear of 1902 will be decreased in even greater proportion, as the effect of the side bearings on the service in general approaches its limit. The service of 52 ore cars equipped with the roller bearings was compared to that of 52 cars with plain side bearings (the car numbers selected at random) for 1900.

While no wheels whatever were removed from the 52 cars with the roller bearings, 17 wheels were taken from the cars with plain bearings for having the flanges worn. By comparing 300 ore and flat cars with the automatic frictionless side bearings with 300 cars with plain bearings for 1901, it was found that while 101 wheels were removed for sharp flanges from the cars having plain side bearings, only 16 wheels were removed for having the flanges worn, from those cars equipped with the automatic frictionless side bearings.

The question of the effect of the automatic frictionless side bearings on flange wear alone is presented, because the wear of the wheel flanges can be easily and definitely ascertained, but while the other economies and advantages are equally apparent, they cannot be so accurately determined. It will be readily appreciated, however, that this reduction in flange wear shown means an equivalent reduction in rail wear, and a proportionate decrease in the draft of trains, and consequently a reduction in the cost of transportation. Again, the capacity and the life of the car bolsters are increased, and the cost of truck repairs considerably lessened. H. S. Bryan, Master Mechanic.

CONCLUSIONS.

Taking up the divisions of this subject, as outlined at the beginning of this report, (1) a design of center plate, your committee presents the results of tests already made, which show the necessity for further tests in order to determine conclusively what should be the minimum area of contact of plates under definite loads, the shape of plate and kind of material. Owing to lack of time and the necessity for redesigning the machine, in order to complete the tests, your committee would ask to be continued another year, in order that it may complete its work. Attention is called to the reduction in flange resistance by lubrication, the lubricant being a thick grease.

As already stated, the second and third divisions of this subject, namely, (2) location of side bearings and (3) the relation between side bearings and center plates, are so closely allied to the first, that your committee has nothing definite to recommend in this connection at the present time. The replies received to the circular of inquiry from 18 members show a variation in distance, center to center, of side bearings and center plates, from 24 ins. to 32½ ins. The height of center plates varies from 2½ ins. to 7 ins.

*January and February.

†An unusual condition affected this year's record. Over 60% of the removals, after deducting the wheels taken out for sharp flanges, were removed for flattened wheels in service.

‡The automatic frictionless side bearings were in service all this year and affecting flange wear.

§No removals for sharp flanges on cars with roller bearings.

As to the merits of anti-friction side bearings for relieving the center plate from part of the load, from the replies received from the members it would seem that opinion is about equally divided. Your committee is of the opinion, however, that with a center plate of proper design and material and a truck and body bolster of sufficient strength, the load can and should be carried on but one bearing point, namely, the center plate.

As to the fifth subject, resistance between wheels and rails, it is the opinion of your committee, and this opinion is substantiated almost unanimously by the replies received from the members, that the use of anti-friction side bearings will diminish this resistance.

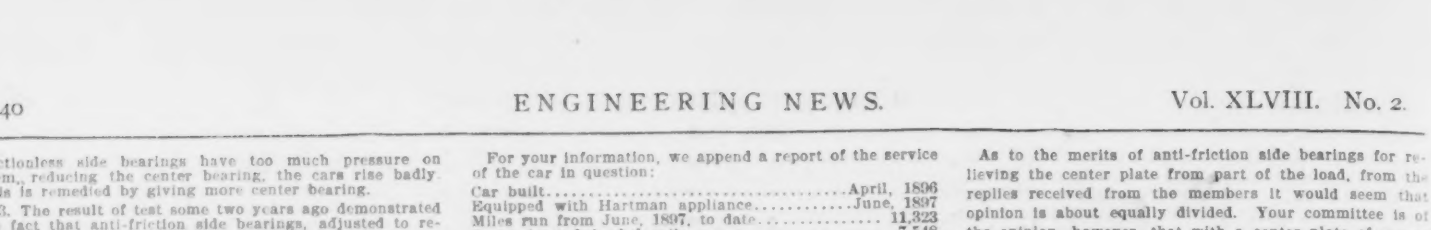
Attention is further called to the fact that when side bearings are in contact the pressure against wheel flanges is greater than with center plates alone in contact.

COMBINATION HIGHWAY AND ELECTRIC RAILWAY BRIDGE OVER MISSOURI RIVER, ST. CHARLES, MO.

We illustrate in the accompanying cuts an elevation of the main spans of a new highway and electric railway bridge which is to be built across the Missouri River at St. Charles, Mo. This structure will be located at the foot of Adams St. in the city of St. Charles, and will cross the river almost perpendicular to the general direction of the stream.

The lowest portion of the superstructure will be 58 ft. above the standard high-water level which provides ample headroom for the passage of boats beneath any part of the bridge. The clear width of roadway is to be 20 ft. between hand rails, and the distance between central planes of trusses will be 22 ft. 6 ins. The vertical clearance will be nowhere less than 15 ft. The spans are to be designed strong enough to carry a double-track motor line between the trusses and a ten-foot clear roadway cantilevered outside of each truss. The outside roadways will not be put on at first, but the space between trusses will be used for both the roadway and motor traffic, until such time as the traffic demands more room, when the outside roadways will be added.

Commencing at Second St. in the city of St. Charles, the structure will consist of 145 ft. of earth embankment, held in place by concrete retaining walls; 525 ft. of timber trestle in Adams St. with a steel span over Main St.; three 416-ft. through spans, and one 300-ft. through span, all of steel, over the river; and several hundred feet of timber trestle on the east side of the river.



COMBINATION HIGHWAY AND ELECTRIC RAILWAY BRIDGE OVER THE MISSOURI RIVER AT ST. CHARLES, MO.
Waddell & Hedrick, Kansas City, Mo., Engineers.

The river spans are to rest on five steel cylinder piers filled with Portland cement concrete, all sunk to bedrock by the pneumatic process. The bedrock varies in depth from 10 ft. below extreme low water on the St. Charles side to 70 ft. below low water on the St. Louis side of the river. About 1,600 tons of steel will be required for the superstructure, and 450 tons for the substructure. The total cost of the bridge and approaches will be over $300,000. All parts of the structure are to be designed and constructed in accordance with the best modern practice.

The bridge will be operated as a toll bridge. The St. Louis, St. Charles & Western Ry. Co. will run their electric motor cars over the structure, thus providing direct rapid transit communication between the cities of St. Louis and St. Charles. J. D. Houseman, of St. Charles, Mo., is General Manager of the St. Charles & St. Louis Counties Bridge Co. and of the St. Louis, St. Charles & Western Ry. Co. The contract for the entire structure has been awarded to the Midland Bridge Co., of Kansas City, Mo., and actual construction will commence as soon as the high water is over. The entire structure is to be completed by July, 1903. The firm of Waddell & Hedrick, Consulting Engineers, of Kansas City, have prepared the plans and will supervise the construction.